GOVERNMENT OF MALAWI

MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT

SHIRE VALLEY IRRIGATION PROJECT

Geotechnical Investigation Report

(FINAL)

Technical Feasibility Study
on Shire Valley Irrigation Project

November 2016

KOREA RURAL COMMUNITY CORPORATION

in Joint Venture with

DASAN CONSULTANTS CO., LTD.,

GK WORKS CIVIL AND STRUCTURAL ENGINEER

Executive Summary

Introduction

The purpose of the investigation was to determine the surface and subsurface conditions of the project site including determination for the physical, chemical and mechanical properties of subsurface ground materials based on the analysis of collected samples from site location and field testing and examination, in order to assist in the design and construction of the proposed project.

Percussive Drilling and Auger Boring

The geotechnical investigation comprised field surveys, laboratory tests and material surveys. As stipulated in the ToR, the Consultant selected 28 points along the canal for geotechnical investigations, covering the Main Canal 1 as well as the entire route of the canal where percussive drilling and auger boring was done. Additionally, 20 points were selected along the canal for permeability tests. Each site for geotechnical investigation was checked through the reconnaissance survey for ease of accessibility with regard to the geotechnical investigation equipment. And as stated in the preceding discussion, the investigations were conducted using percussive drilling or auger boring.

The geotechnical investigations and laboratory test were done in accordance with the Malawi's recommended standards. Standard penetration test (SPT) was carried out in boreholes at intervals of 1.5m. In addition to SPT, samples were collected from boreholes at intervals of 1.5m for laboratory testing.

- Geotechnical investigation works included the following;
  a) Percussive drilling and Auger boring,
  b) Standard penetration test,
  c) Disturbed and undisturbed soil sampling,
  d) Permeability test and laboratory tests for disturbed and undisturbed soil samples.

- Laboratory tests included the following;
  a) Atterberg limits,
  b) Sieve analysis,
  c) Triaxial test,
  d) Unit weight and specific gravity.

Scope of Geotechnical Survey

Geotechnical surveys involved field activities and laboratory work. Field activities were carried out in accordance with BS 5903 of 1990, and the laboratory activities were carried out in accordance with BS 1377 of 1991. Details of field and laboratory activities are as followings;

- Field Activities;
  a) Location of borehole positions

b) Drilling of 19 boreholes
c) Collection of disturbed & undisturbed samples
d) Carrying out standard penetration tests at an interval of 1.5 m
e) Excavation of Permeability pits to maximum of 1.0 m
f) Collection of samples for permeability test
g) Logging of each borehole and each permeability pit
h) Carrying out of 3 sand replacement tests
i) Carry out 9 Auguring holes
j) Carrying out G/pits surveys
k) Carrying out quarry surveys
l) Carrying out of unit weight tests

- Laboratory Activities;

a) Determination of sieve analysis
b) Determination of atterberg limits
c) Permeability test
d) Specific gravity
e) Natural moisture content
f) Determination of Maximum dry density
g) Determination of Aggregate Crushing Value

Survey Result

The geological map of Malawi reveals that the proposed Shire Valley Irrigation Project is partly within the Shire Highlands and mostly within the Lower Shire Valley Plains. From the intake site, soil characteristics reveal the existence of charnockitic suite: banded pyroxene granulites and gneisses, and hyperthene-granite of precabrian palaezoic late origin. Alluvium of quarternary origin occurs from the foot of the escarpment to Kamuzu Bridge to Majete and Bangula.

The composition of field activities during the operation of the survey included the following: 19 boreholes were drilled, 20 permeability pits were excavated, 9 Auguring holes were sunk, 89 disturbed samples were collected for sieve analysis and atterberg limit tests, 40 Natural moisture content tests were performed in the laboratory, 20 permeability tests were conducted in the laboratory, and 3 sand replacement test were done. These activities were done along the proposed canal lines and within the command area.

The drilling depths of the boreholes were decided based on the bed elevations of canal, and the drilling were executed up to the 1 m below those elevations.

Boreholes: the following boreholes were drilled at various strategic points along the canal lines and within the command area:

- BH A Comprises of 2 layers and it was drilled to maximum of 2.65m.
- BH 1 Comprises of 6 layers and it was drilled to maximum of 6.47m.
- BH 2 Comprises of 6 layers and it was drilled to maximum of 6.5m.
- BH 3 Comprises of 3 layers and it was drilled to maximum of 9.70m.
- BH 4 & 5 were drilled to maximum of 2.235m on average.
- BH 7a Comprises of 3 layers and it was drilled to maximum of 1.30m.

- BH 6, 7 & 9 were drilled to maximum of 3.45m on average.
- BH 12, 13 & 14 were drilled to maximum of 4.15m on average.
- BH 15 & 16 were drilled to maximum of 3.45m each.
- BH 18 Comprises of 6 layers and it was drilled to maximum of 6.45m.
- BH 22 was drilled to maximum of 3.0m.
- BH 23 & 24 were drilled to maximum of 3.175m on average

Rock layers were found at BH-ABH-4, BH-9, BH-13, 14, 15, situated 2 ~ 3m below the ground surface. The earth layer in each borehole is 2 m thick from the ground surface and comprises sand, silt, and clay. Granular material was found along the Main Canal 1 section, and is equivalent to A-1(A-1-a, A-1-b), A-2(A-2-4~7) following the AASHTO Soil Classification System. Samples collected from this proposed site have been analyzed and fall into 5 (five) main soil subgroups of A-1, A-2, A-4, A-6 & A-7. The three soil subgroup of A-1, A-2 and A-7 are good quality of soil characteristics for civil works.

The first subgroups of A-4 & A-6 are poor soils which are plastic and having high volume changes, with fluctuating moisture content. Therefore, their expansive and contracting characteristics should be taken into account when designing structures. A-4(Silt), A-6(Sand) soil groups exist along the Main Canal 1 and 2 sections, located within 3 m depth from the ground surface. These soils are recommended to be replaced or treated during canal construction for the persistence of structures. In terms of the construction conditions this will not be a substantial constraint.

The second subgroups of A-2-4, A-2-6 & A-2-7 are fairly to good soils which are not highly plastic, A-2-4 & A-2-5 have maximum plasticity index of 10%, and A-2-6 & A-2-7 soil subgroups have a minimum plasticity index of 11%.

The third subgroups of A-1-a & A-1-b are good to excellent soils which have very low plasticity index (PI) of not more than 6% or are Non Plastic (NP).

Borrow Pits: the following borrow pits were dug and quarry sites investigated for determining appropriate sites as sources of construction materials:

8 borrow pits and 4 quarry sites were investigated to be a source of construction materials for the proposed Shire Valley Irrigation Project. Borrow pits investigated are Tomali, Nyaika, Sibale old pit, Nyamithuthu old pit, Chikhama, Moroko, Chikalumpha and Namiche. Quarry sites investigated are Kajawo, Thabwa existing quarry, Nzongwe and Ngabu. Characteristics of all the sites investigated are as follows:

- Tomali gravel pit: 2 main soil subgroups of A-2-4 and A-2-6 were identified, with CBR values of 16 % at 95 and 18% at 98
- Nyaika gravel pit: 2 main soil subgroups of A-2-6 and A-2-7 were identified, with CBR values of 30 % at 95 and 74% at 98
- Sibale gravel pit: 1 main subgroup of A-1-a was identified, with CBR values of 54% at 95 and 65% at 98
- Nyamithuthu old pit: 2 main subgroups of A-1-a and A-2-4 were identified, with CBR values of 54 % at 95 and 74% at 98
- Chikhamba, Namacha and Chikalimba borrow pits: 3 main subgroups of A-1-a, A-2-4 & A-2-6 were identified, with CBR values of 22 % at 95 and 48% at 98, 34 %at 95 and 42% at 98 & 16 % at 95 and 27% at 98 respectively

- Moroko gravel pit: 3 main soil subgroups of A-6, A-2-6 & A-2-7were identified, with CBR values of 24 % at 95 and 25% at 98
- Kajawo quarry site produces aggregate with a crushing value of 35.3%
- Thabwa quarry site produces aggregate with a crushing value of 30.1%
- Nzongwe quarry site produces aggregate with a crushing value of 43.0%
- Ngabu quarry site produces aggregate with a crushing value of 22.0%

Ngabu quarry site qualifies to be the source of construction material for the roads because the crushing value falls within the not more than 25% specification. Kajawo and Thabwa quarry sites can be used as sources of quarry for concrete works because the crushing values fall within the not more than 35% specification for concrete works. Nzongwe quarry site is unsuitable as a source of construction materials because the crushing values fall outside the specification for both roads and concrete works.

Kajawo and Thabwa quarry sites shall be the main source of quarry material. These sites are near to each other and located at the bottom of the escarpment at the entrance into the Lower Shire Valley Plain from Blantyre. The distance between these sites and Majete Game Reserve, which is the farthest points of the main canals, is about 20 km.

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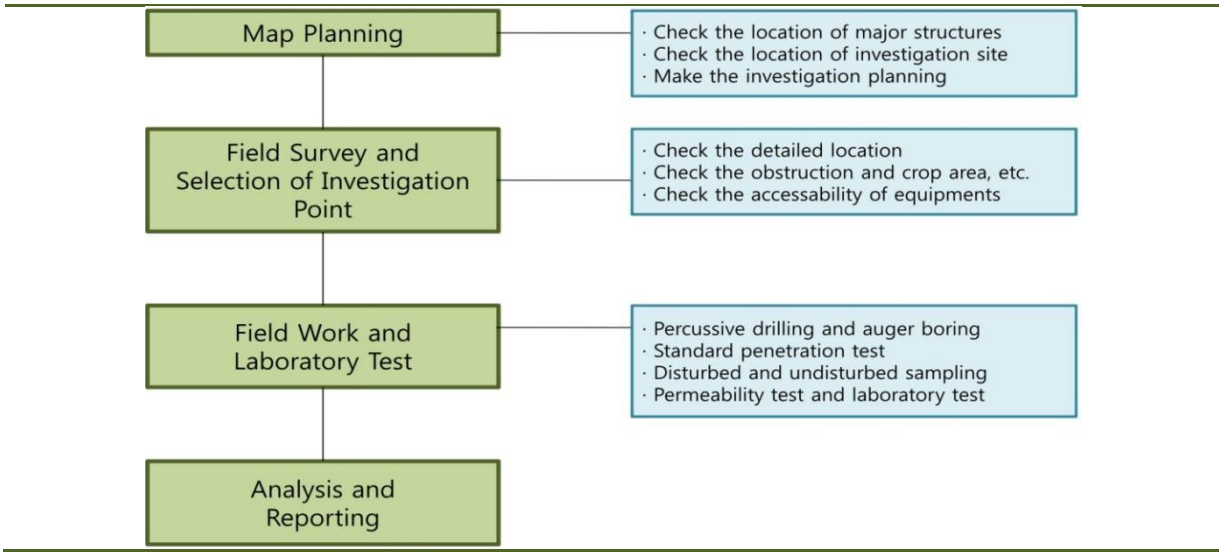
1. Overview of Geotechnical Investigation

This report is presenting the geotechnical investigation results and evaluations for the site for the proposed Shire Valley Irrigation Scheme Project (SVIP) which was subjected to this investigation for the preliminary design of the canal from Majete through to Illovo and Bangula, in Chikwawa District.

Geotechnical investigation was implemented two times: January 2016 and April 2016. The purpose of the investigation was to determine the surface and subsurface conditions of the project site including determination for the physical, chemical and mechanical properties of subsurface ground materials based on the analysis of collected samples from site location and field testing and examination, in order to assist in the design and construction of the proposed project.

The geotechnical investigation focused on the Main Canal 1, Main Canal 2 and Main Canal 3, and the general procedure of geotechnical investigation is as follows;



[Figure 1.1] Flow Chart of Geotechnical Investigation

2. First Geotechnical Investigation

2.1. Percussive Drilling and Auger Boring

The geotechnical investigation comprised field surveys, laboratory tests and material surveys. As stipulated in the ToR, the Consultant selected 28 points along the canal for geotechnical investigations, covering the Main canal 1 as well as the entire route of the canal where percussive drilling and auger boring was done.

Additionally, 20 points were selected along the canal for permeability tests. Table 2.1 ~ Table 2.4 show the location of investigation sites.

[Table 2.1] Coordination of Percussive Drilling and Auger Boring (Main Canal 1)

Division	Coordination(X)	Coordination(Y)	Division	Coordination(X)	Coordination(Y)
BH-A	686,895	8,243,053	BH-7a	686,827	8,233,919
BH-1	687,065	8,242,376	BH-8	687,227	8,230,525
BH-2	687,002	8,242,353	BH-9	688,103	8,228,704
BH-3	687,016	8,242,312	BH-10	688,807	8,225,246
BH-4	687,007	8,241,230	BH-11	686,596	8,226,466
BH-5	686,463	8,240,248	BH-12	685,911	8,224,369
BH-5a	684,839	8,240,356	BH-13	685,652	8,222,834
BH-6	686,438	8,237,896	BH-14	686,163	8,221,108
BH-7	686,303	8,236,287	BH-15	685,320	8,218,020

[Table 2.2] Coordination of Percussive Drilling and Auger Boring (Main Canal2)

Division	Coordination(X)	Coordination(Y)	Division	Coordination(X)	Coordination(Y)
BH-16	684,049	8,217,595	BH-19	679,938	8,211,724
BH-16a	683,246	8,215,276	BH-20	679,924	8,210,266
BH-17	682,089	8,214,494	BH-21	680,629	8,208,430
BH-18	681,169	8,213,292	BH-22	681,605	8,207,101

[Table 2.3] Coordination of Percussive Drilling and Auger Boring (Main Canal3)

Division	Coordination(X)	Coordination(Y)	Division	Coordination(X)	Coordination(Y)
BH-23	687,273	8,214,217	BH-24	689,558	8,211,321

[Table 2.4] Coordination of Permeability Test

Division	Coordination(X)	Coordination(Y)	Division	Coordination(X)	Coordination(Y)
P/T-1	685,319	8,218,020	P/T-11	698,810	8,182,103
P/T-2	682,089	8,214,494	P/T-12	703,761	8,175,634
P/T-3	679,924	8,210,266	P/T-13	705,858	8,172,694
P/T-4	681,605	8,207,101	P/T-14	707,631	8,171,814
P/T-5	681,278	8,205,535	P/T-15	710,412	8,169,054
P/T-6	683,444	8,204,933	P/T-16	714,797	8,166,150
P/T-7	686,030	8,201,739	P/T-17	717,172	8,165,297
P/T-8	689,191	8,196,727	P/T-18	687,273	8,214,217
P/T-9	693,933	8,191,090	P/T-19	687,345	8,213,157
P/T-10	696,240	8,185,028	P/T-20	689,558	8,211,321

Each site for geotechnical investigation was checked through the reconnaissance survey for ease of accessibility with regard to the geotechnical investigation equipment. And as stated in the preceding discussion, the investigations were conducted using percussive drilling or auger boring.

[Figure 2.1] Drilling Point Check(left) and Percussive Drilling & Standard Penetration Test(right)

The geotechnical investigations and laboratory test were done in accordance with the Malawi's recommended standards. Standard penetration test (SPT) was carried out in boreholes at intervals of 1.5m. In addition to SPT, samples were collected from boreholes at intervals of 1.5m for laboratory testing.

Geotechnical investigation works included the following;

a) Percussive drilling and Auger boring,
b) Standard penetration test,
c) Disturbed and undisturbed soil sampling,
d) Permeability test and laboratory tests for disturbed and undisturbed soil samples.

Laboratory tests included the following;

a) Atterberg limits,
b) Sieve analysis,
c) Triaxial test,
d) Unit weight and specific gravity.

The Consultant supervised the field and laboratory tests and evaluated the results.

2.2. Determining Seepage Losses in the Main Canal 1

The geotechnical tests on the Main canal 1 focused on seepage losses and hydraulic conductivities. Since an infiltrometer was not readily available for use in the determination of seepage losses at the 10 selected points on the Main Canal 1 (Table 2.5), starting with Point 1 at the Intake of the Main Canal 1 and ending with Point 10 close to Road D134, an

alternative method involving digging pits was adopted.

[Table 2.5] List of the Main Structures

Division	Location	Type	Chain No.	Coordination (X,Y)
1 Main 1	Intake	Longitudinal Structure	0+000	687073.6 , 8242379.0
2 Main 1	Road D135	Longitudinal Structure	2+854	686850.7 , 8241561.7
3 Main 1	Road D135	Longitudinal Structure	5+706	686512.7 , 8240341.4
4 Main 1	Mwambezi	Cross sectional drain structure	7+451	685546.3 , 8240111.8
5 Main 1	Namkati	Cross sectional drain structure	15+207	685641.4 , 8236817.1
6 Main 1	Masakale	Cross sectional drain structure	23+092	684964.2 , 8234499.8
7 Main 1	Kadeya	Cross sectional drain structure	29+213	686951.3 , 8232689.9
8 Main 1	Manjalende	Cross sectional drain structure	34+350	687303.0 , 8229997.1
9 Main 1	Nthumba	Cross sectional drain structure	54+620	684998.1 , 8224103.1
10 Main 1	Road D134	Longitudinal Structure	56+447	685678.0 , 8222840.7

The 10 points along the Main Canal 1 were located in the field using a GPS unit. The following steps were thereafter followed in the determination of percolation rates:

(a) Excavation of the soil layer which was to be assessed for percolation rate by digging a pit measuring 1m by 1m and by 0.5m depth. All the loose material was then removed from the sides and bottom of the pit (Figure 2.2);

(b) A smaller pit measuring 300 mm by 300 mm and 300 mm deep was dug in the larger pit (Figure 2.3);

(c) Water was then poured into the small pit to wet the soil, i.e. presoaking, prior to taking measurements of percolation time (Figure 2.4);

(d) After thoroughly wetting the soil, the small pit was then filled with water, noting the time that was taken for the water to drop by 225 mm, with a minimum of 10 minutes considered adequate for recording the percolation time (Figure 2.5); and thereafter

(e) Seepage losses were calculated by dividing the depth of water drop by the time taken. After conducting the percolation test in the field, soil samples were collected from each pit for laboratory testing at the Civil Engineering Laboratory at the Malawi Polytechnic to determine the respective hydraulic conductivities of the soils excavated from the pits using the Darcy's experimental setup.

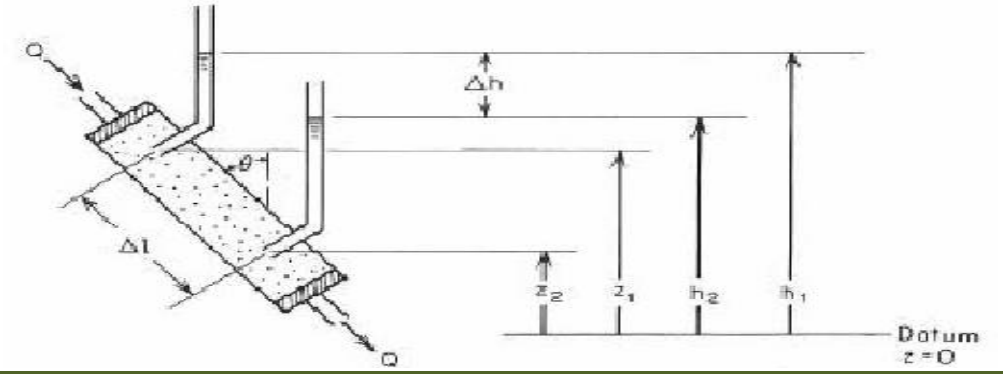
[Figure 2.2] Measuring the Surface Dimension of the Pit (left) and Digging the Pit (right)

[Figure 2.3] The 300mm by 300mm by 300mm Hole

[Figure 2.4] Presoaking the Hole

[Figure 2.5] Recording Time Taken for the Water Level to Drop to 225 mm

After conducting the percolation test in the field, soil samples were collected from each pit for laboratory testing at the Civil Engineering Laboratory at the Malawi Polytechnic to determine the respective hydraulic conductivities of the soils excavated from the pits using the Darcy's experimental setup as shown in Figure 2.6.



[Figure 2.6] Laboratory Setup for Permeability Test

[Figure 2.7] Permeability Test

2.3. Geotechnical Assessment

Presented in Table 2.6 is brief descriptions of soil profiles exhibited by the pits excavated at the 10 selected points along the Main canal 1.

[Table 2.6] Description of Soil Profiles

Site Number	Description of Soil Profile
1	0-400 mm, dark brownish soil, comprising clays, fine sands, and humus; >400 mm, reddish brown soil, containing clays and fine sands.
2	0-300 mm, black soil, consisting of clays, fine sands, and humus; >300 mm, loamy sandy soil
3	0-250 mm, reddish brown soil, comprising fine sands and clays; >250 mm, reddish brown sandy soil.
4	0-400 mm, dark brownish soil, containing fine sands and clays; >400 mm, brownish sandy soil.
5	0-300 mm, dark greyish soil, with fine sands and clay; >300 mm, decomposed metamorphic rock of gneiss origin, with feldspars
6	0-400 mm, dark brownish soils, containing fine sands and clays; >400 mm, brownish sandy soil
7	0-400 mm, decomposed rock of gneiss origin, with feldspars; >400 mm, decomposed rock
8	0-400 mm, dark brownish soil, comprising clays and fine sands; >400 mm brownish sandy soils
9	0-400 mm, decomposed lateritic rock; >400 mm, decomposed lateritic rock.
10	0-330 mm, dark brownish soil, comprising clays and fine sands; >330 mm, reddish sandy loam soils

It is clear from the description of the soil profiles that the soils along the Main canal 1 are generally sandy in nature comprising clays and humus. As such, conveyance losses due to seepage expected to take place, therefore in this point of view lining of canal is recommended. Especially inside Majete area, the lined Main canal 1 is highly recommended to minimize the seepage loss. In this regard a buried concrete siphon could be considered as another option. During the preliminary design the pros and cons of the two alternatives shall be carefully assessed, and selected the more advantageous one.

[Figure 2.8] Soil Samples Collected from the 10 Points on the Feeder Canal

Presented in Table 2.7 and Table 2.8, respectively, are the results of the percolation and soil permeability tests conducted at Points 1 to 10 on the Main canal 1.

[Table 2.7] Results of the Percolation Test

Site Number	Time Elapsed (min)	Total Water Drop (mm)	Percolation Rate (mm/sec)
1	18	221	0.20
2	21	150	0.12
3	10	225	0.38
4	32	180	0.09
5	24	220	0.15
6	20	200	0.17
7	23	220	0.16
8	21	120	0.10
9	10	140	0.23
10	10	95	0.16

Note: Percolation Rate = Total Water Drop/Time Elapsed

[Table 2.8] Results of Soil Permeability

Sample No.	Hydraulic Gradient	Length of Sample (mm)	Volume (cm^3)	Time (min)	Coefficient of Permeability (mm/sec)
1	6.52	225	562	45	0.063
2	6.52	226	540	45	0.061
3	6.52	226	594	45	0.067
4	6.52	226	952	45	0.108
5	6.52	225	2580	45	0.291
6	6.52	225	1660	45	0.187
7	6.52	225	2160	45	0.244
8	6.52	226	584	45	0.066
9	6.52	226	844	45	0.095
10	6.52	226	440	45	0.050

Note from the preceding discussion that,

$$Q = -KA\frac{dh}{dl}$$

Where, K is the permeability, Q is the discharge, A is the cross-sectional area of flow, and dh/dl is the hydraulic gradient.

According to the soil classification developed by Myslivec and Kysela (1978), the soils excavated at the 10 pits fall within the group of Loess Loam (Table 2.9), with coefficient of permeability in the range of 10^{-2} to 10^{-4}.

[Table 2.9] Permeability for Various Soils (Source: Myslivec and Kysela, 1978)

Type of Soil	Coefficient of Permeability k [m/day]	Motion of Water Particle by1 cm for Hydraulic Gradient i = 1 per time
Soft sand	10^{2} - 10	6 s - 10 min
Clayey sand	10^{-1} - 10^{-2}	100 min - 18 hrs
Loess loam	10^{-2} - 10^{-4}	18 hrs - 70 days
Loam	10^{-4} - 10^{-5}	70 days - 2 years
Clayey soil	10^{-5} - 10^{-6}	2 years - 20 years
Clay	10^{-6} - 10^{-7}	20 years - 200 years

2.4. Result of First Investigation

Study findings show that the area that will be traversed by the Main canal 1 comprises sandy soils which will likely result in high seepage losses if the canal is not going to be paved or lined with concrete. Additionally, it has been recommended to use concrete pipes buried in the ground to be used as a water conveyance system so as to reduce evaporation losses and to protect wild animals from drowning.

3. Second Geotechnical Investigation

Second geotechnical surveys were carried out for the proposed SVIP. The purpose of the geotechnical surveys was to determine the surface and subsurface conditions at specific points within the project area including the physical, chemical and mechanical properties of subsurface materials in order to;

- Evaluate the geotechnical engineering conditions of the project area in order to assist in the design and construction of the most suitable and economical structures.
- Evaluate the corrosiveness of the site materials to assist in the selection of most suitable construction materials and protection measures.
- To evaluate the permeability of the ground to come up with economical treatment.
- Determine the soil parameters for safe and economical design of the structures.

3.1. Scope of Geotechnical Survey

Geotechnical surveys involved field activities and laboratory work. Field activities were

carried out in accordance with BS 5903 of 1990, and the laboratory activities were carried out in accordance with BS 1377 of 1991. Details of field and laboratory activities are given in Table 3.1.

[Table 3.1] Details of Field and Laboratory Activities

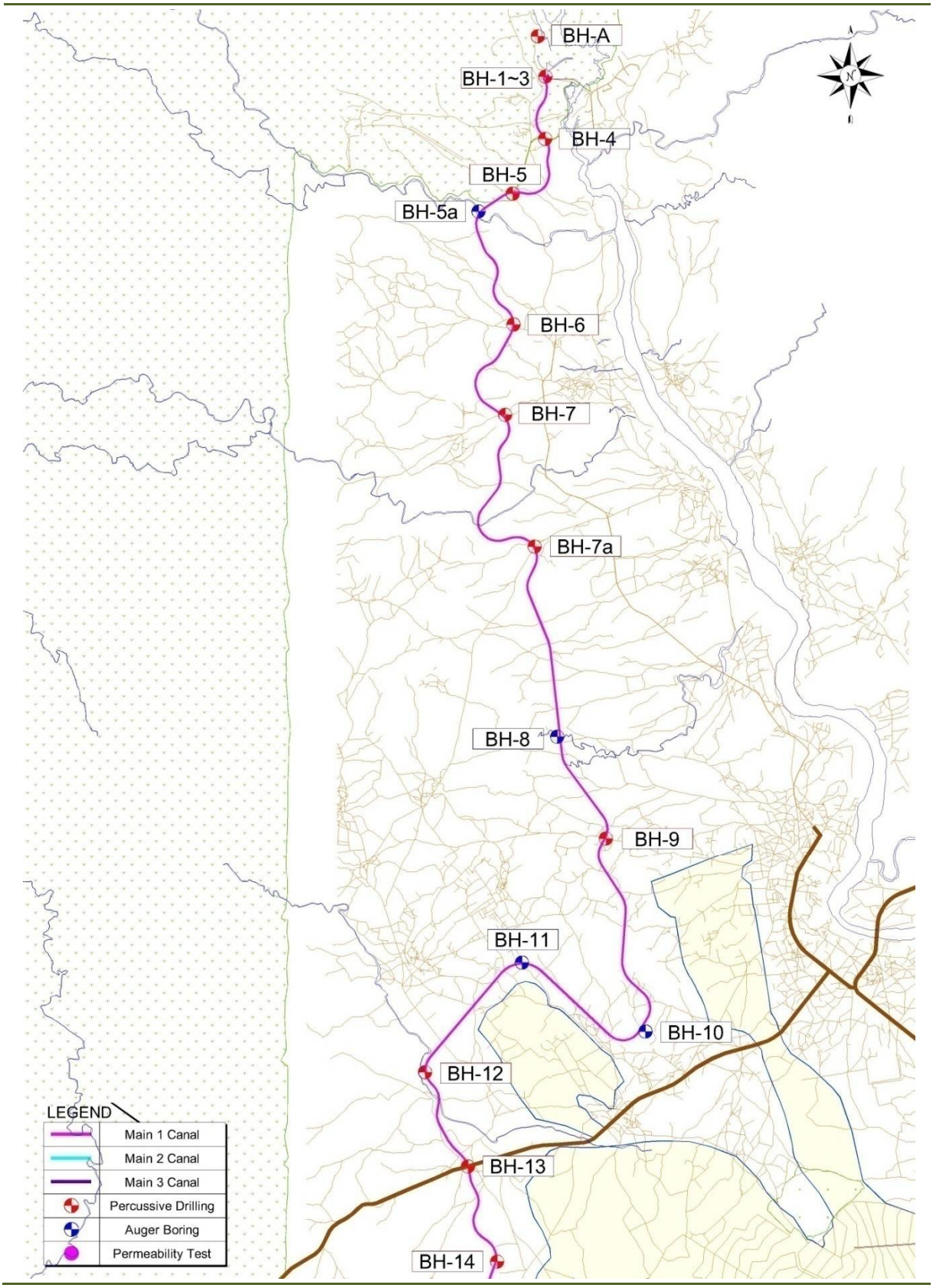
Item	Tasks
Field Activities	Location of borehole positions
	Drilling of 19 boreholes
	Collection of disturbed & undisturbed samples
	Carrying out standard penetration tests at an interval of 1.5 m
	Excavation of Permeability pits to maximum of 1.0 m
	Collection of samples for permeability test
	Logging of each borehole and each permeability pit
	Carrying out of 3 sand replacement tests
	Carry out 9 Auguring holes
	Carrying out G/pits surveys
	Carrying out quarry surveys
	Carrying out of unit weight tests
Laboratory Activities	Determination of sieve analysis
	Determination of atterberg limits
	Permeability test
	Specific gravity
	Natural moisture content
	Determination of Maximum dry density
	Determination of Aggregate Crushing Value

3.2. Result of Second Investigation

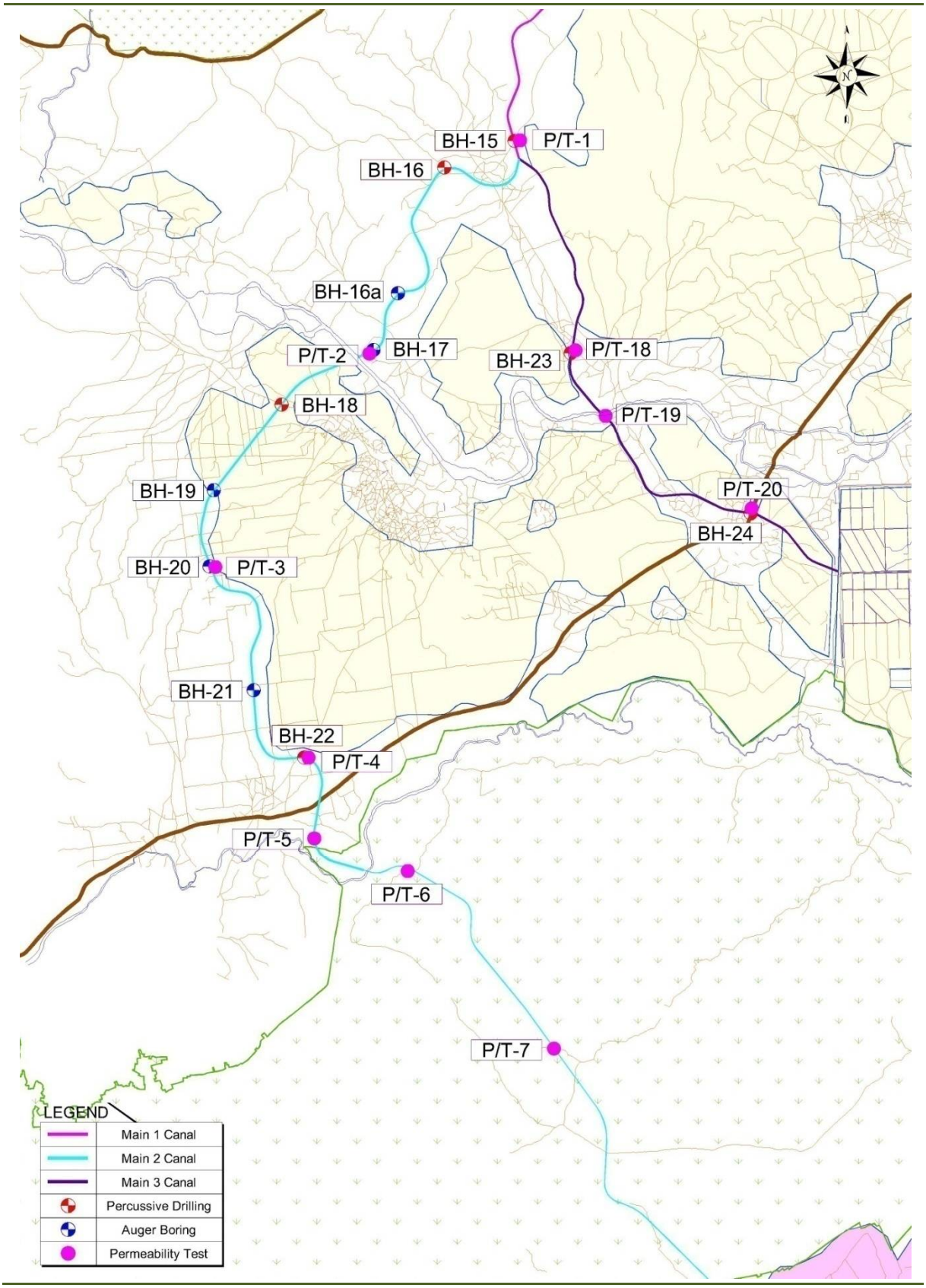
The geological map of Malawi reveals that the proposed Shire Valley Irrigation Project is partly within the Shire Highlands and mostly within the Lower Shire Valley Plains. From the intake site, soil characteristics reveal the existence of charnockitic suite: banded pyroxene granulites and gneisses, and hyperthene-granite of precabrian palaezoic late origin. Alluvium of quarternary origin occurs from the foot of the escarpment to Kamuzu Bridge to Majete and Bangula.

The composition of field activities during the operation of the survey included the following: 19 boreholes were drilled, 20 permeability pits were excavated, 9 Auguring holes were sunk, 89 disturbed samples were collected for sieve analysis and atterberg limit tests, 40 Natural moisture content tests were performed in the laboratory, 20 permeability tests were conducted in the laboratory, and 3 sand replacement test were done. These activities were

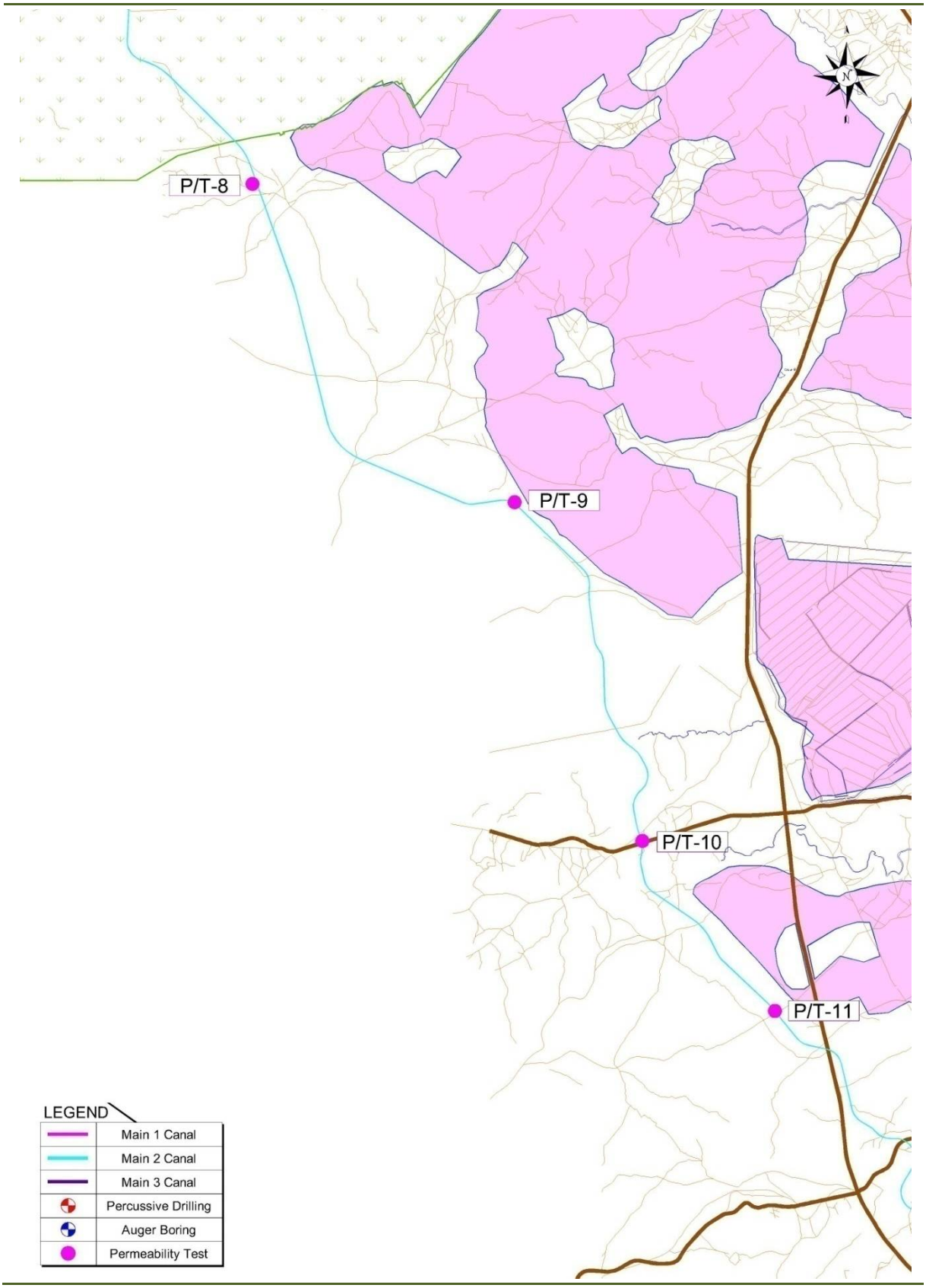
done along the proposed canal lines and within the command area. The various locations are depicted in Figure 3.1 ~ Figure 3.4.



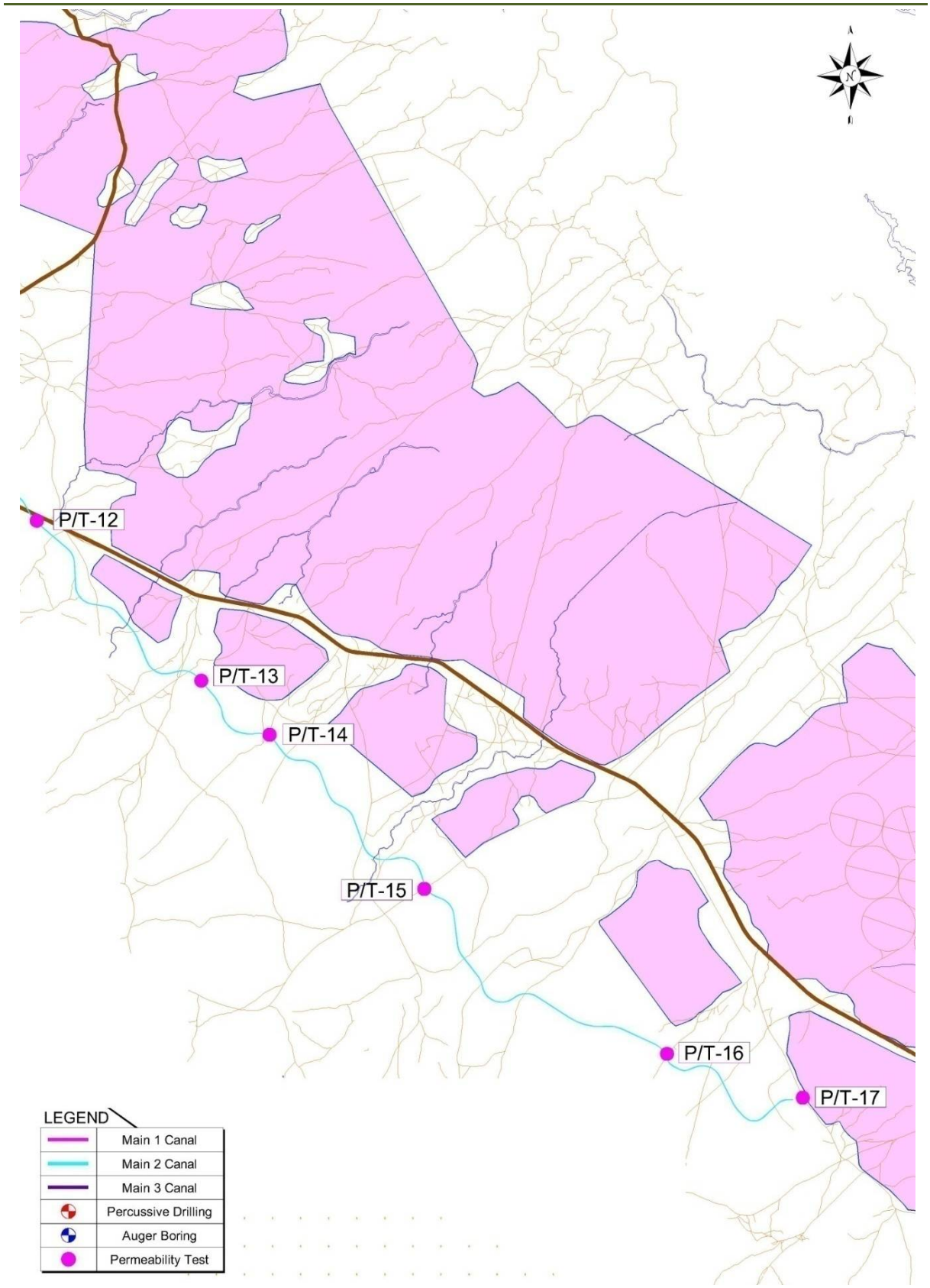
[Figure 3.1] Location Map of Geotechnical Investigation -1



[Figure 3.2] Location Map of Geotechnical Investigation -2



[Figure 3.3] Location Map of Geotechnical Investigation -3



[Figure 3.4] Location Map of Geotechnical Investigation -4

The drilling depths of the boreholes were decided based on the bed elevations of canal, and the drilling were executed up to the 1 m below those elevations.

3.2.1. Boreholes

Boreholes: the following boreholes were drilled at various strategic points along the canal lines and within the command area:

- BH A Comprises of 2 layers and it was drilled to maximum of 2.65m.
- BH 1 Comprises of 6 layers and it was drilled to maximum of 6.47m.
- BH 2 Comprises of 6 layers and it was drilled to maximum of 6.5m.
- BH 3 Comprises of 3 layers and it was drilled to maximum of 9.70m.
- BH 4 & 5 were drilled to maximum of 2.235m on average.
- BH 7a Comprises of 3 layers and it was drilled to maximum of 1.30m.
- BH 6, 7 & 9 were drilled to maximum of 3.45m on average.
- BH 12, 13 & 14 were drilled to maximum of 4.15m on average.
- BH 15 & 16 were drilled to maximum of 3.45m each.
- BH 18 Comprises of 6 layers and it was drilled to maximum of 6.45m.
- BH 22 was drilled to maximum of 3.0m.
- BH 23 & 24 were drilled to maximum of 3.175m on average

Drilling of Borehole	Laboratory Test
	

[Figure 3.5] Drilling of Borehole and Laboratory Test

Samples collected from this proposed site have identified themselves into 5 (eight) main soil subgroups of A-1, A-2, A-4, A-6 & A-7. Rock layers were found at BH-ABH-4, BH-9, BH-13, 14, 15, situated 2 ~ 3m below the ground surface. The earth layer in each borehole is 2 m thick from the ground surface and comprises sand, silt, and clay. Granular material was found along the Main canal 1 section, and is equivalent to A-1(A-1-a, A-1-b), A-2(A-2-4~7)

following the AASHTO Soil Classification System. Samples collected from this proposed site have been analyzed and fall into 5 (five) main soil subgroups of A-1, A-2, A-4, A-6 & A-7. The three soil subgroup of A-1, A-2 and A-7 are good quality of soil characteristics for civil works.

The first subgroups of A-4 & A-6 are poor soils which are plastic and having high volume changes, with fluctuating moisture content. Therefore, their expansive and contracting characteristics should be taken into account when designing structures. A-4(Silt), A-6(Sand) soil groups exist along the Main Canal 1 and 2 sections, located within 3 m depth from the ground surface. These soils are recommended to be replaced or treated during canal construction for the persistence of structures. In terms of the construction conditions this will not be a substantial constraint.

The second subgroups of A-2-4, A-2-6 & A-2-7 are fairly to good soils which are not highly plastic, A-2-4 & A-2-5 have maximum plasticity index of 10%, and A-2-6 & A-2-7 soil subgroups have a minimum plasticity index of 11%.

The third subgroups of A-1-a & A-1-b are good to excellent soils which have very low plasticity index (PI) of not more than 6% or are Non Plastic (NP).

3.2.2. Borrow Pits

Borrow Pits: the following borrow pits were dug and quarry sites investigated for determining appropriate sites as sources of construction materials:

8 borrow pits and 4 quarry sites were investigated to be a source of construction materials for the proposed Shire Valley Irrigation Project. Borrow pits investigated are Tomali, Nyaika, Sibale old pit, Nyamithuthu old pit, Chikhama, Moroko, Chikalumpha and Namiche. Quarry sites investigated are Kajawo, Thabwa existing quarry, Nzongwe and Ngabu. Characteristics of all the sites investigated are as follows:

- Tomali gravel pit: 2 main soil subgroups of A-2-4 and A-2-6 were identified, with CBR values of 16 % at 95 and 18% at 98
- Nyaika gravel pit: 2 main soil subgroups of A-2-6 and A-2-7 were identified, with CBR values of 30 % at 95 and 74% at 98
- Sibale gravel pit: 1 main subgroup of A-1-a was identified, with CBR values of 54% at 95 and 65% at 98
- Nyamithuthu old pit: 2 main subgroups of A-1-a and A-2-4 were identified, with CBR values of 54 % at 95 and 74% at 98
- Chikhamba, Namacha and Chikalimba borrow pits: 3 main subgroups of A-1-a, A-2-4 & A-2-6 were identified, with CBR values of 22 % at 95 and 48% at 98, 34 %at 95 and 42% at 98 & 16 % at 95 and 27% at 98 respectively
- Moroko gravel pit: 3 main soil subgroups of A-6, A-2-6 & A-2-7were identified, with CBR values of 24 % at 95 and 25% at 98

- Kajawo quarry site produces aggregate with a crushing value of 35.3%
- Thabwa quarry site produces aggregate with a crushing value of 30.1%
- Nzongwe quarry site produces aggregate with a crushing value of 43.0%
- Ngabu quarry site produces aggregate with a crushing value of 22.0%

Ngabu quarry site qualifies to be the source of construction material for the roads because the crushing value falls within the not more than 25% specification. Kajawo and Thabwa quarry sites can be used as sources of quarry for concrete works because the crushing values fall within the not more than 35% specification for concrete works. Nzongwe quarry site is unsuitable as a source of construction materials because the crushing values fall outside the specification for both roads and concrete works.

Kajawo and Thabwa quarry sites shall be the main source of quarry material. These sites are near to each other and located at the bottom of the escarpment at the entrance into the Lower Shire Valley Plain from Blantyre. The distance between these sites and Majete Game Reserve, which is the farthest points of the main canals, is about 20 km.

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APPENDIX

A. Sketch Plans

B. Gravel Quantities

C. Quarry Results

D. Borehole Logs

E. Test Results (Boreholes)

F. Gravel Test Results

G. Borehole Unit Weight & NMC

H. Auguring, Unit Weight & NMC

I. Auguring Test Results

J. Permeability Test Results

K. Location Picture

L. Field Pictures

M. Lab Pictures

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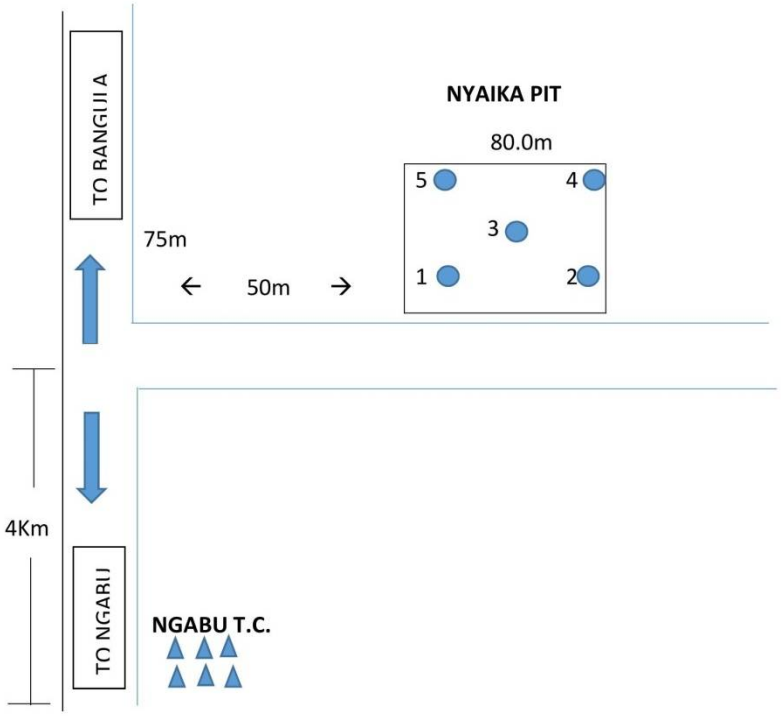
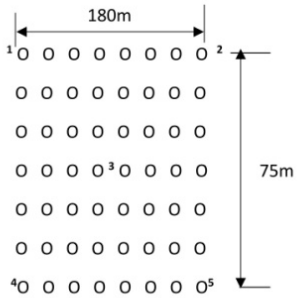
Appendix A. Sketch Plans

NYAIKA OLD PIT



PROPOSED BORROW AREAS

PROJECT: SHIRE VALLEY IRRIGATION PROJECT **SOURCE: NYAIKA OLD B/PIT**



PIT No	DEPTH OF OVERBURDEN(m)	THICKNESS OF GRAVEL(m)
1	0.00	0.80
2	0.00	0.63
3	0.00	0.75
4	0.00	0.80
5	0.00	0.90

PIT No	DEPTH OF OVERBURDEN(m)	THICKNESS OF GRAVEL(m)

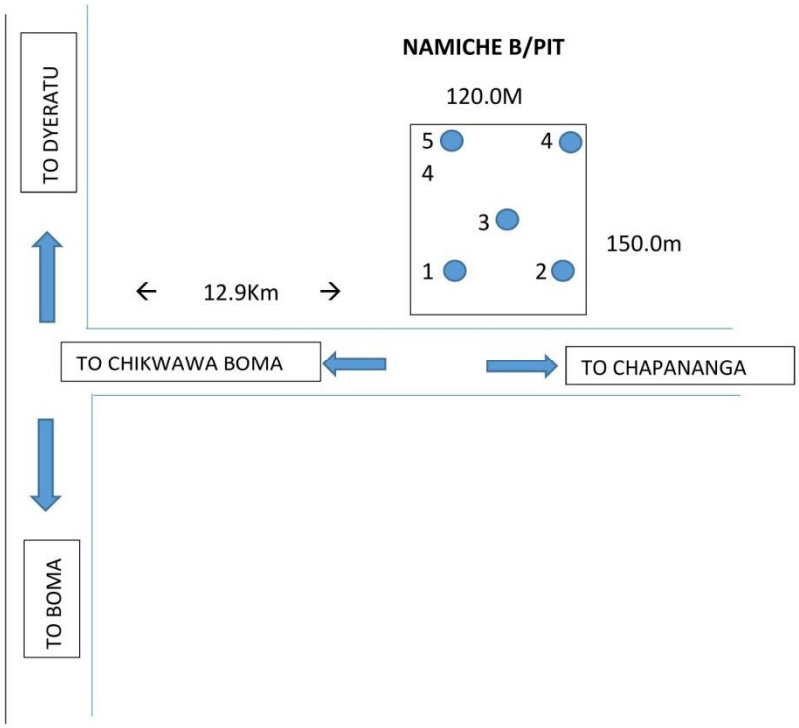
AVERAGE DEPTH OF OVERBURDEN=0.00

AVERAGE THICKNESS OF GRAVEL=0.75

ESTIMATED AVAILABLE QUANTITY (GROSS) =4,500m^3

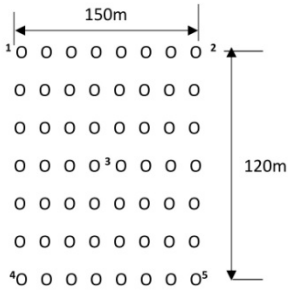
ESTIMATED AVAILABLE QUANTITY (NETT) (ALLOWING FOR 25% WASTAGE) =3,375m^3

NAMICHE B/PIT



PROPOSED BORROW AREAS

PROJECT: SHIRE VALLEY IRRIGATION PROJECT **SOURCE: NAMICHE B/PIT**



PIT No	DEPTH OF OVERBURDEN(m)	THICKNESS OF GRAVEL(m)
1	0.00	0.57
2	0.00	0.59
3	0.00	0.53
4	0.00	0.53
5	0.00	0.55

PIT No	DEPTH OF OVERBURDEN(m)	THICKNESS OF GRAVEL(m)

AVERAGE DEPTH OF OVERBURDEN=0.00m

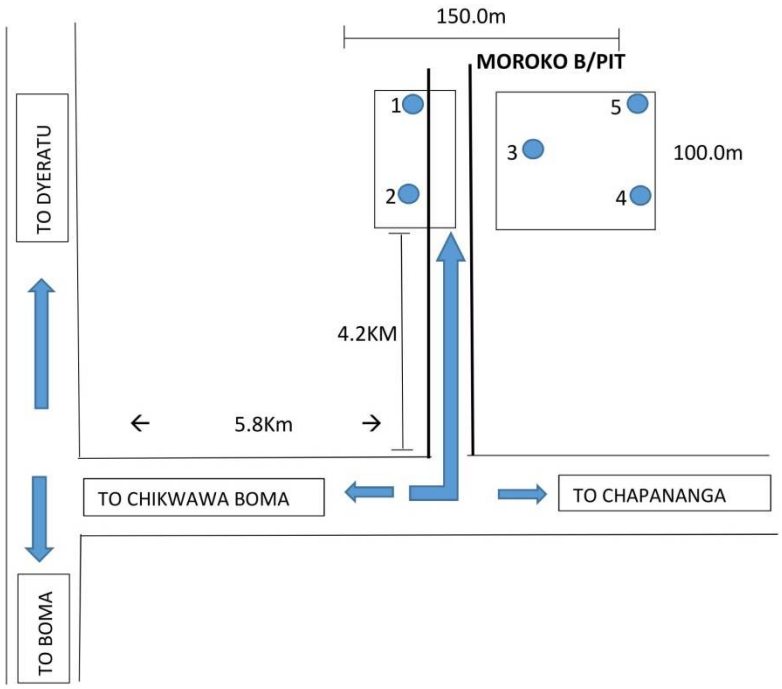
AVERAGE THICKNESS OF GRAVEL=0.53m

ESTIMATED AVAILABLE QUANTITY (GROSS) =9,540m^3

ESTIMATED AVAILABLE QUANTITY (NETT) (ALLOWING FOR 25% WASTAGE) =7,155m^3

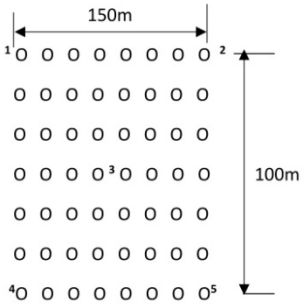
MOROKO B/PIT

MOROKO B/PIT



PROPOSED BORROW AREAS

PROJECT: SHIRE VALLEY IRRIGATION PROJECT **SOURCE: MOROKO B/PIT**



PIT No	DEPTH OF OVERBURDEN(m)	THICKNESS OF GRAVEL(m)
1	0.00	0.72
2	0.00	0.90
3	0.00	0.60
4	0.00	0.70
5	0.00	0.70

PIT No	DEPTH OF OVERBURDEN(m)	THICKNESS OF GRAVEL(m)

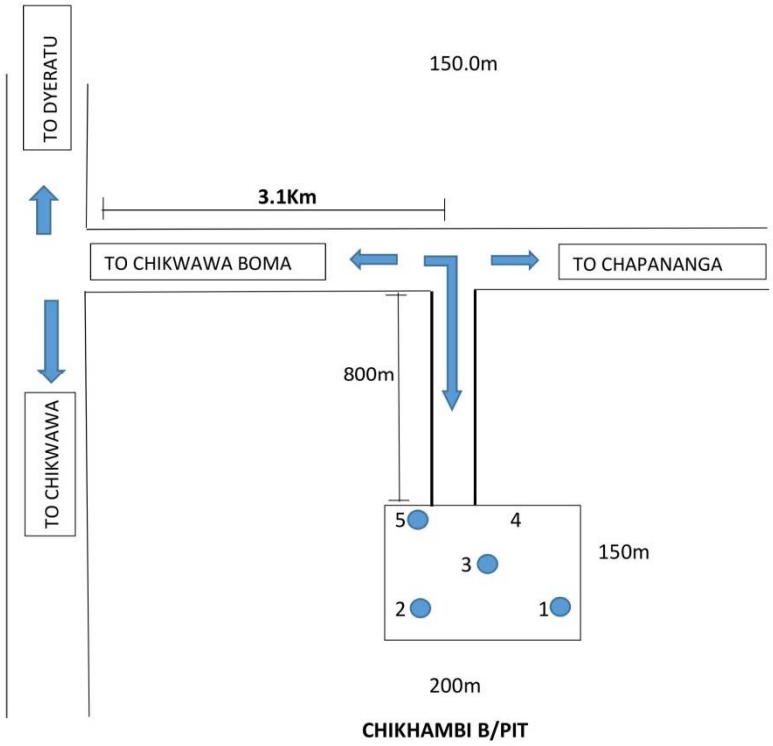
AVERAGE DEPTH OF OVERBURDEN=0.00

AVERAGE THICKNESS OF GRAVEL=0.724

ESTIMATED AVAILABLE QUANTITY (GROSS) =10,860m^3

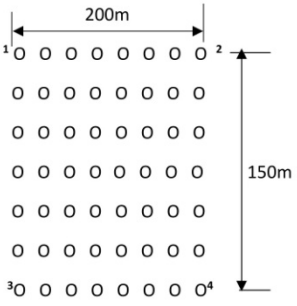
ESTIMATED AVAILABLE QUANTITY (NETT) (ALLOWING FOR 25% WASTAGE) =8,145m^3

CHIKHAMBI B/PIT



PROPOSED BORROW AREAS

PROJECT: SHIRE VALLEY IRRIGATION PROJECT **SOURCE: CHIKHAMBI B/PIT**



PIT No	DEPTH OF OVERBURDEN(m)	THICKNESS OF GRAVEL(m)
1	0.00	1.60
2	0.00	0.65
3	0.00	0.61
4	0.00	0.82

PIT No	DEPTH OF OVERBURDEN(m)	THICKNESS OF GRAVEL(m)

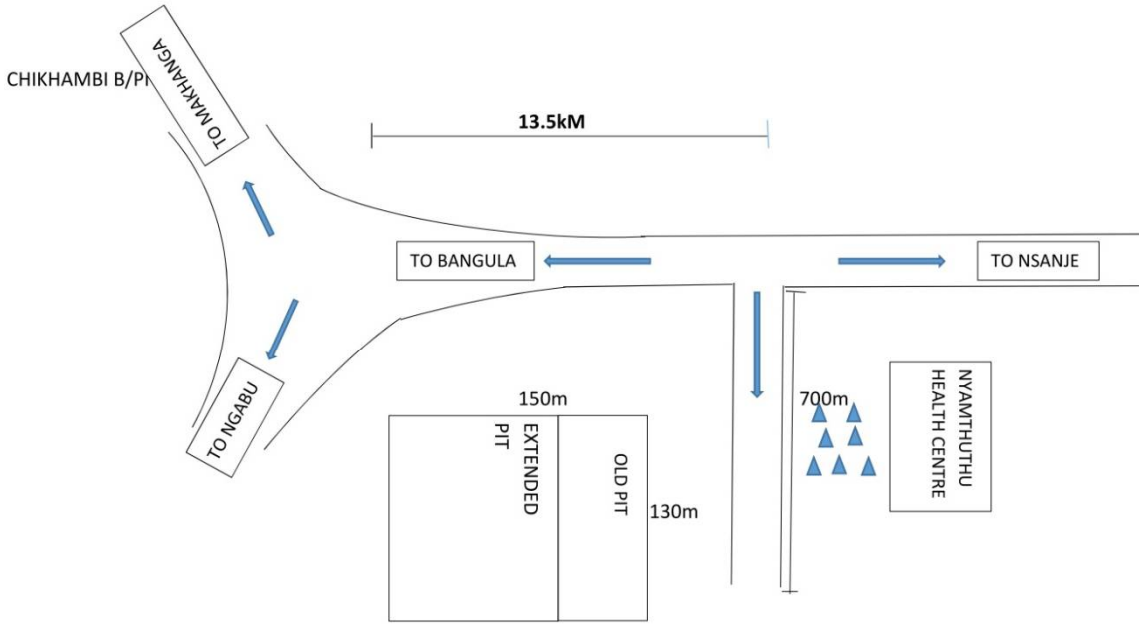
AVERAGE DEPTH OF OVERBURDEN=0.00

AVERAGE THICKNESS OF GRAVEL=0.92

ESTIMATED AVAILABLE QUANTITY (GROSS) =27,600m^3

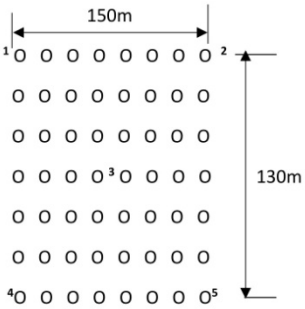
ESTIMATED AVAILABLE QUANTITY (NETT) (ALLOWING FOR 25% WASTAGE) =20,700m^3

NYAMITHUTHU B/PIT



PROPOSED BORROW AREAS

PROJECT: SHIRE VALLEY IRRIGATION PROJECT **SOURCE: NYAMITHUTHU B/PIT**



PIT No	DEPTH OF OVERBURDEN(m)	THICKNESS OF GRAVEL(m)
1	0.00	1.00
2	0.00	1.20
3	0.00	1.50
4	0.00	1.40
5	0.00	1.20

PIT No	DEPTH OF OVERBURDEN(m)	THICKNESS OF GRAVEL(m)

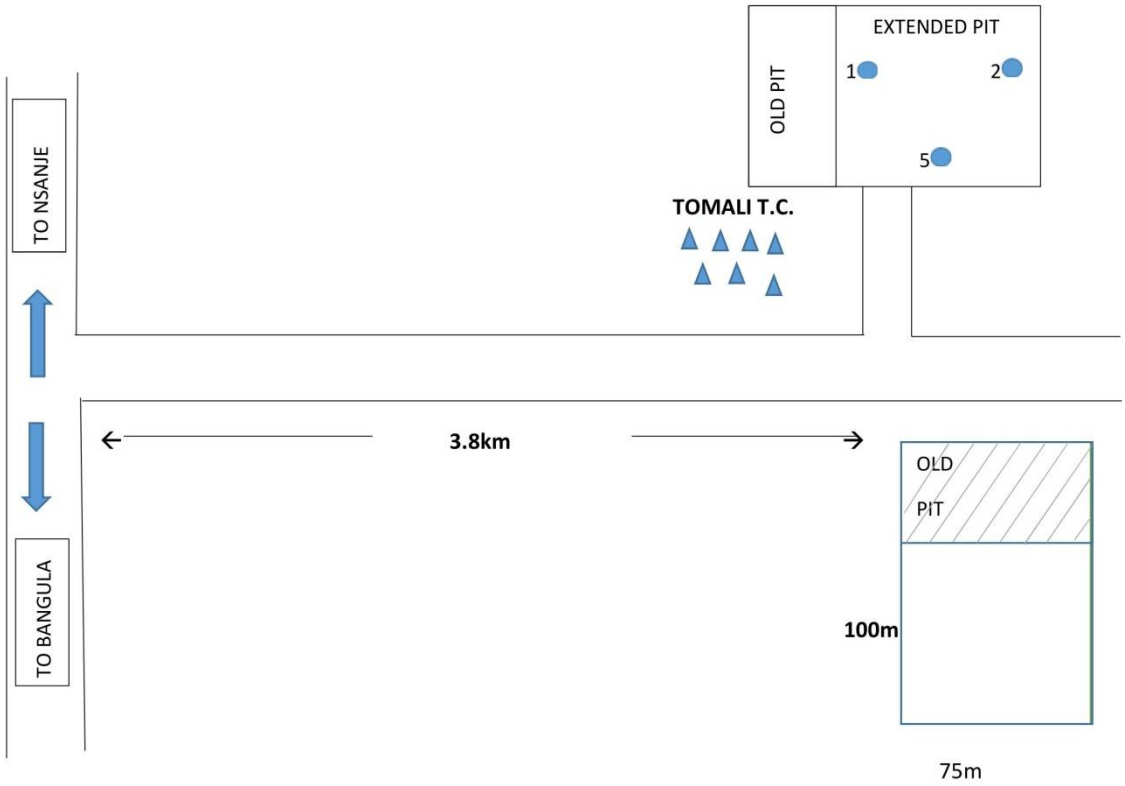
AVERAGE DEPTH OF OVERBURDEN=0.00

AVERAGE THICKNESS OF GRAVEL=1.26

ESTIMATED AVAILABLE QUANTITY (GROSS) =24,570m^3

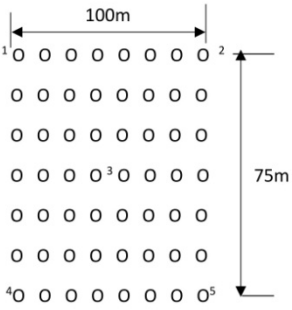
ESTIMATED AVAILABLE QUANTITY (NETT) (ALLOWING FOR 25% WASTAGE) =18,428m^3

SIBALE OLD PIT



PROPOSED BORROW AREAS

PROJECT: SHIRE VALLEY IRRIGATION PROJECT **SOURCE: SIBALE B/PIT**



PIT No	DEPTH OF OVERBURDEN(m)	THICKNESS OF GRAVEL(m)
1	0.00	1.00
2	0.00	0.90
3	0.00	1.07
4	0.00	0.84
5	0.00	1.00

PIT No	DEPTH OF OVERBURDEN(m)	THICKNESS OF GRAVEL(m)

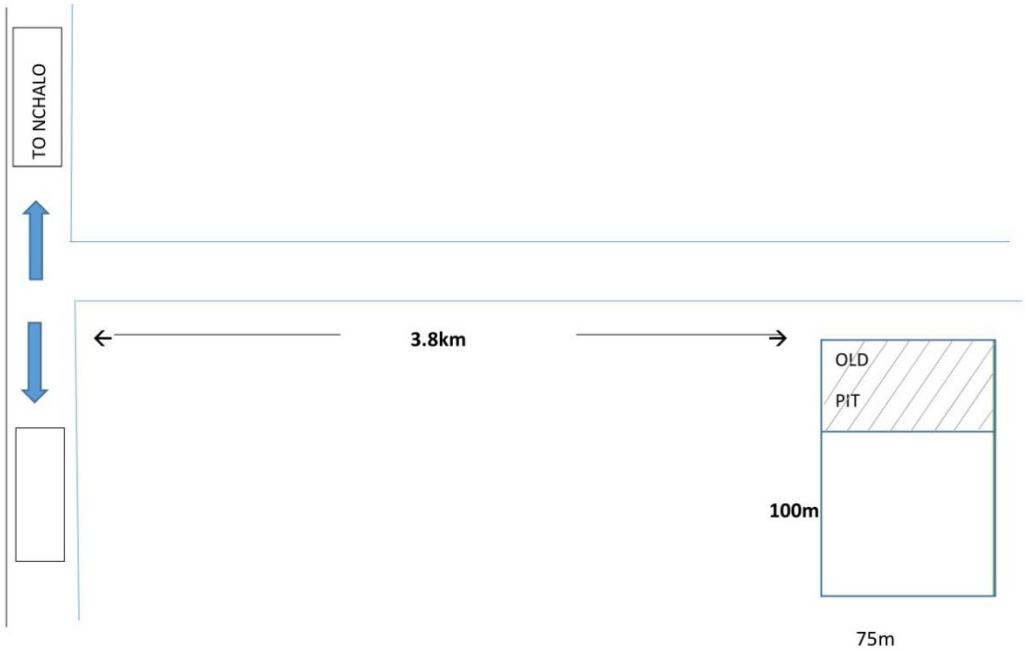
AVERAGE DEPTH OF OVERBURDEN=0.00

AVERAGE THICKNESS OF GRAVEL=0.96

ESTIMATED AVAILABLE QUANTITY (GROSS) =7,200m^3

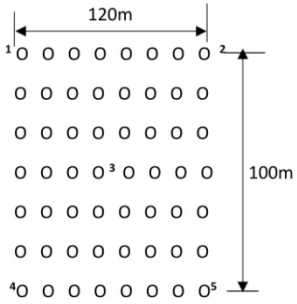
ESTIMATED AVAILABLE QUANTITY (NETT) (ALLOWING FOR 25% WASTAGE) =5,400m^3

TOMALI EXTENDED PIT



PROPOSED BORROW AREAS

PROJECT: SHIRE VALLEY IRRIGATION PROJECT **SOURCE: TOMALI EXTENDED B/PIT**



PIT No	DEPTH OF OVERBURDEN(m)	THICKNESS OF GRAVEL(m)
1	0.00	0.68
2	0.00	0.99
3	0.00	0.53
4	0.00	0.53
5	0.00	0.55

PIT No	DEPTH OF OVERBURDEN(m)	THICKNESS OF GRAVEL(m)

AVERAGE DEPTH OF OVERBURDEN=0.00

AVERAGE THICKNESS OF GRAVEL=0.76

ESTIMATED AVAILABLE QUANTITY (GROSS) =9,120m^3

ESTIMATED AVAILABLE QUANTITY (NETT) (ALLOWING FOR 25% WASTAGE) =6,840m^3

Appendix B. Gravel Quantities

SHIRE VALLEY IRRIGATION PROJECT

CHIKHAMBA BORROW PIT

SOIL PROFILE

TP NO	GPS	DEPTH M	DESCCRIPTION
1	36L 0689155 UTM 8225369	0.00-1.60	Dark brown weathered ROCK
2	36L 0689149 UTM 8225415	0.00-0.65	Light brown weathered ROCK
3	36L 0689160 UTM 8225462	0.00-0.60	Light brown weathered ROCK
4	36L 0689228 UTM 8225422	0.00-085	Light brown weathered ROCK

SHIRE VALLEY IRRIGATION PROJECT

MOROKO BORROW PIT

SOIL PROFILE

TP NO	GPS	DEPTH M	DESCCRIPTION
1	36L 0686049 UTM 8219265	0.00-0.72	Reddish brown weathered ROCK
2	36L 0686070 UTM 8219240	0.00-0.90	Dark brown weathered ROCK
3	36L 0635988 UTM8219314	0.00-0.60	Light brown weathered ROCK
4	36L 0686021 UTM 8219340	0.00-0.70	Dark brown weathered ROCK
5	36L 0686091 UTM 8219267	0.00-0.70	Light brown weathered ROCK

SHIRE VALLEY IRRIGATION PROJECT

CHIKALUMPHA BORROW PIT

SOIL PROFILE

TP NO	GPS	DEPTH M	DESCCRIPTION
1	36L 0682596 UTM 8220757	0.00-0.6	Light brown quartz GRAVEL
2	36L 0682686 UTM 8220727	0.00-0.73	Light brown weathered ROCK
3	36L 0682758 UTM 8220743	0.00-0.60	Light brown weathered ROCK
4	36L 0682745 UTM 8220779	0.00-0.58	Light brown weathered ROCK

SHIRE VALLEY IRRIGATION PROJECT

NAMICHE BORR

OW PIT

SOIL PROFILE

TP NO	GPS	DEPTH	DESCRIPTION
1	36L 0681935 UTM 8219928	0.00-0.57	Light brown decomposed ROCK
2	36L 0681963 UTM 8219963	0.00-0.59	Light brown weathered ROCK
3	36L 0681961 UTM 8219945	0.00-0.53	Light brown weathered ROCK
4	36L 0681961 UTM 8219945	0.00-0.53	Light brown weathered ROCK
5	36L 0681940 UTM 8212975	0.00-0.55	Light brown weathered ROCK

SHIRE VALLEY IRRIGATION PROJECT
TOMALI BORRO
W PIT

SOIL PROFILE

TP NO	GPS	DEPTH	DESCRIPTION
1	36L 0687851 UTM 0687851	0.00-0.68	Reddish brown weathered ROCK
2	36L 0687877 utm 8211396	0.00-0.99	Greyish brown weathered ROCK
3	36L 0687891 UTM 8211440	0.00-0.53	Light brown weathered ROCK
4	36L 06887896 UTM 8211581	0.00-0.53	Light brown weathered ROCK
5	36L 0681940 UTM 8212975	0.00-0.55	Light brown weathered ROCK

SHIRE VALLEY IRRIGATION PROJECT
NYAIKA BORROW
PIT

SOIL PROFILE

TP NO	GPS	DEPTH	DESCRIPTION
1	36L 0702854 UTM 8175508	0.00-0.80	Dark grey weathered ROCK
2	36L 0702840 UTM 8175476	0.00-0.63	Greyish brown weathered ROCK
3	36L 0687891 UTM 8175504	0.00-0.75	Greyish brown weathered ROCK
4	36L 0702961 UTM 8175517	0.00-0.80	Reddish brown weathered ROCK
5	36L 0702531 UTM 8175568	0.00-0.90	Whitish grey weathered ROCK

SHIRE VALLEY IRRIGATION PROJECT
SIBAHE BORROW PIT

SOIL PROFILE

TP NO	GPS	DEPTH	DESCRIPTION
1	36L 0724964 UTM 8158935	0.00-1.00	Whitish grey weathered ROCK
2	36L 0724902 UTM 8158975	0.00-0.90	Light brown weathered ROCK
3	36L 0724890 UTM 8158999	0.00-1.07	Greyish brown weathered ROCK
4	36l 0724873 UTM 8158976	0.00-0.84	Whitish weathered ROCK
5	36L 0724893 UTM 8158952	0.00- 1.00	Greyish brown weathered ROCK

SHIRE VALLEY IRRIGATION PROJECT
NYAMITHUTHU BORROW PIT

SOIL PROFILE

TP NO	GPS	DEPTH	DESCRIPTION
1	36L 0734238 UTM 8154373	0.00-1.00	Light brown quartz GRAVEL
2	36L 0734228 UTM 8154387	0.00-1.20	Light brown quartz GRAVEL
3	36L 0734194 UTM 8154407	0.00-1.50	Light brown quartz GRAVEL
4	36L 0734195 UTM 8154371	0.00-1.40	Light brown quartz GRAVEL
5	36L 0734219 UTM 8154363	0.00- 1.20	Light brown quartz GRAVEL

Appendix C. Quarry Results

MINISTRY OF TRANSPORT & PUBLIC WORKS
CENTRAL MATERIALS LABORATORY

CLIENT: KRC – DASAN & GK WORKS **LAB No.: 875/ACV/2016**
PROJECT: SHIRE VALLEY IRRIGATION PROJECT **OPERATOR: J. MASEYA**
DATE: 24/05/2016

QUARRY LOCATION	ACV	F.I	E.I	ORGANIC CONTENT
Kajawa	35.3	23	19	CLEAN
Thabwa	30.1	21	14	CLEAN
Nzongwe	29.0	26	20	CLEAN
Ngabu	22.0	20	18	CLEAN
Remarks:				

Appendix D. Borehole Logs

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**						36L 0686863 UTM 8242746		
LOCATION	**:**		**CHIKWAWA**						SURVEYED BY:		**E. KACHALE**
GROUND ELEV:			-						LOGGED BY:		**J. MASEYA**
GROUND WATER LEV:									DATE:		**4/4/2016**
BORE HOLE NO.:			**BH A**								
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**		
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN**	**IN**	**IN**	**VALUE**	**OF**		**REMARKS**
					150mm	**150mm**	**150mm**	**300mm**	**MATERIAL**		
	0.00										
			0.40						Loose dark brown clayey silty SAND		
	1.00										
			1.70	SPT	55++						**48mm penetr**
	2.00								Filrm light brown clayey silty SAND with		
			2.18						some stones		**END OF BH**

UD	=	**Undisturbed Sample**	*-*-*-*-*	=	**Sand**
N	=	**SPT N-Value**		=	**Gravel**
D	=	**Disturbed Sample**		=	**Silt**
				=	**Clay**
				=	**Decomposed Rock**

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			LOWERSHIRE VALLEY IRRIGATION						36K 0687007, UTM 8242013		
LOCATION	:		CHIKWAWA						SURVEYED BY:		E. KACHALE
GROUND ELEV	:		-						LOGGED BY:		J. MASEYA
GROUND WATER LEVEL									DATE:		4/2/2016
BORE HOLE NO.			1								
ELEV	DEPTH		DEPTH	SAMPLE	NUMBER OF BLOWS			SPT N	DESCRIPTION		
(m)	(m)	GRAPHIC	(m)	TYPE	IN 150mm	IN 150mm	IN 150mm	VALUE 300mm	OF MATERIAL		REMARKS
	0.00										
			0.75						Loose dark brown sandy silty CLAY		
	1.00										
			1.50	SPT	9	10	6	16			
	2.00		1.90						Firm reddish brown clayey silty sand with		
									some particles of weathered ROCK		
	3.00										
			3.00	SPT	5	10	15	25			
	4.00		3.25						Firm light brown sandy SILT		
			3.47						Dense light brown fine SAND		
			4.50	SPT	17	17	29	46			
	6.00		5.20						Dense light brown medium to coarse sand		
									mixed with some PEBBLES		
			6.33	SPT	33	55++					140 pentration
	7.00		6.47						Dense dark brown medium SAND with		
				SPT	3	5	8	13	some pebbles		
									mixed with pebbles		END OF B.H.

UD	=	Undisturbed Sample		= Sand	
N	=	SPT N-Value		= Gravel	
D	=	Disturbed Sample		= Silt	
				= Clay	
				= Decomposed Rock	

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**						36K 0686995 UTM 8241999		
LOCATION	**:**		**CHIKWAWA**						SURVEYED BY:		**E. KACHALE**
GROUND ELEV:									LOGGED BY:		**J. MASEYA**
GROUND WATER LEVEL:									DATE:		**4/2/2016**
BORE HOLE	**:**		**2**								
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**		
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN 150mm**	**IN 150mm**	**IN 150mm**	**VALUE 300mm**	**OF MATERIAL**		**REMARKS**
	0.00		0.50						Loose dark brown clayey sandy SILT		
		--*-*-*-*									
			1.95	**SPT**	9	10	9	19			
	1.00	*-*-*-*-*-*	1.97						Firm reddish brown clayey silty SAND		
									Dense light brown weathered ROCK		
	2.00		2.96						with some cobbles		
		--*-*-*-*									
	3.00	*-*-*-*-*-*									
		--*-*-*-*	3.45	SPT	4	9	14	23			
	4.00										
	5.00		4.95	SPT	8	16	22	38			
		--*-*-*-*	5.22						Firm light brown sandy SILTY		
	6.00	*-*-*-*-*-*	5.50						Dense light brown medium SAND		
		--*-*-*-*	6.50	SPT		55++					**Pentr 70mm**
	7.00	*-*-*-*-*-*									

UD	**=**	**Undisturbed Sample**	*-*-*-*-*	**=**	**Sand**
N	**=**	**SPT N-Value**		**=**	**Gravel**
D	**=**	**Disturbed Sample**		**=**	**Silt**
				=	**Clay**
				=	**Decomposed Rock**

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**						36K 0686985 UTM 824159		
LOCATION	**:**		**CHIKWAWA**						SURVEYED BY:		**E. KACHALE**
GROUND ELEV:			-						LOGGED BY:		**J. MASEYA**
GROUND WATER LEV:									DATE:		**4/2/2016**
BORE HOLE NO.:			**3**								
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**		
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN**	**IN**	**IN**	**VALUE**	**OF**		**REMARKS**
					150mm	**150mm**	**150mm**	**300mm**	**MATERIAL**		
	0.00		0.20						Loose dark brown silt SAND		
		--*-*-*-*									
		--*-*-*-*	0.55						Film greyish brown clayey SAND		Fill material
		--*-*-*-*							mixed with quarry stone		
	1.00	*-*-*-*-*-*									
			1.25						Firm dark brown sandy silty CLAY with		
									some particles of weathered ROCK		
		--*-*-*-*	1.45						Stiff dark brown silty sandy silty clay		
									mixed with quartz GRAVEL		
			1.50	SPT	9	10	12	22			
	2.00	*-*-*-*-*-*									
		--*-*-*-*									
		--*-*-*-*	2.68						Firm light brown clayey SAND with some		
		--*-*-*-*							particles of weathered ROCK		
	3.00		3.00	SPT	11	14	19	33			
	4.00										
			4.50	SPT	14	9	21	30			
	5.00	*-*-*-*-*-*									
		--*-*-*-*	**5.45**						Firm yellowish brown silty clayey SAND		
		--*-*-*-*									
	6.00			SPT	17	21	22	43			
			6.25						Firm light brown sandy SILT		
		--*-*-*-*									
	7.00	*-*-*-*-*-*	7.50	SPT	8	19	21	40			
		--*-*-*-*	**7.50**						Dense fine SAND with some pebbles		
		--*-*-*-*									
	8.00	*-*-*-*-*-*									
		--*-*-*-*									
		--*-*-*-*	**8.75**						Dense greyish medium SAND		
	9.00	*-*-*-*-*-*									
		--*-*-*-*	**9.55**	SPT		55++			Dense greyish medium to coarse SAND		No penetr
		--*-*-*-*							with some pebbles		
		--*-*-*-*									

UD	**=**	**Undisturbed Sample**	*-*-*-*-*	**=**	**Sand**
N	**=**	**SPT N-Value**		**=**	**Gravel**
D	**=**	**Disturbed Sample**		**=**	**Silt**
				=	**Clay**
				=	**Decomposed Rock**

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MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**						36K 0686945 UTM 8240902	
LOCATION :			**CHIKWAWA**						SURVEYED BY:	**E. KACHALE**
GROUND ELEV:			-						LOGGED BY:	**J. MASEYA**
GROUND WATER LEV:									DATE:	**4/2/2016**
BORE HOLE NO.:			4							
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**	
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN 150mm**	**IN 150mm**	**IN 150mm**	**VALUE 300mm**	**OF MATERIAL**	**REMARKS**
	0.00		0.64						Very loose dark brown clayey silty SAND	
		--*-*-*-*								
		--*-*-*-*								
			0.95						Loose dark brown clayey sandy SILT	
	1.00									
			1.75						Whitish grey weathered ROCK	
			1.95	SPT	8	9	11	20		
	2.00									
	3.00									
			3.02	SPT	55++				Hard greyish brown decomposed ROCK	**20mm penetr**

UD	=	**Undisturbed Sample**	*-*-*-*-*	=	**Sand**
N	=	**SPT N-Value**		=	**Gravel**
D	=	**Disturbed Sample**		=	**Silt**
				=	**Clay**
				=	**Decomposed Rock**

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT:			**LOWERSHIRE VALLEY IRRIGATION**						36L 0686466 UTM 8239849	
LOCATION	**:**		**CHIKWAWA**						SURVEYED BY:	**E. KACHALE**
GROUND ELEV:			**-**						LOGGED BY:	**J. MASEYA**
GROUND WATER LEV:									DATE:	**4/4/2016**
BORE HOLE NO.:			**5**							
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**	
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN**	**IN**	**IN**	**VALUE**	**OF**	**REMARKS**
					150mm	**150mm**	**150mm**	**300mm**	**MATERIAL**	
	0.00									
		--*-*-*-*	0.85						Loose greyish brown clayey	imported
		--*-*-*-*							some gravels	material
	1.00	*-*-*-*-*-*								
		--*-*-*-*								
		--*-*-*-*	1.50	**SPT**	7	11	9	20		
	2.00									
			2.82						Firm dark brown sandy silty CLAY	
	3.00	*-*-*-*-*-*	3.00	SPT	8	11	11	22		
			3.45						Firm light brown clayey sandy SILT	**END OF B.H.**

UD	**=**	**Undisturbed Sample**	*-*-*-*-*-	**= Sand**	
N	**=**	**SPT N-Value**		**= Gravel**	
D	**=**	**Disturbed Sample**		**= Silt**	
				= Clay	
				= Decomposed Rock	

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**						36K 0686464 UTM 8237567	
LOCATION :			**CHIKWAWA**						SURVEYED BY:	**E. KACHALE**
GROUND ELEV:			-						LOGGED BY:	**J. MASEYA**
GROUND WATER LEV:									DATE:	**4/4/2016**
BORE HOLE NO.:			**6**							
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**	
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN 150mm**	**IN 150mm**	**IN 150mm**	**VALUE 300mm**	**OF MATERIAL**	**REMARKS**
	0.00									
		--*-*-*-*								
			0.61						Loose dark brown silty sandy CLAY	
		--*-*-*-*								
	1.00									
			1.50	**SPT**	7	9	9	18		
			1.90						Firm yellowish brown sandy silty CLAY	
	2.00									
		--*-*-*-*								
			2.56						Firm light brown silty sandy with particles of weathered ROCK	
		--*-*-*-*								
	3.00		3.00	SPT	8	13	13	26		
			3.45						Firm ligth brown sandy SILT	**END OF B.H.**

UD	=	**Undisturbed Sample**	*-*-*-*-*-*	= **Sand**	
N	=	**SPT N-Value**		= **Gravel**	
D	=	**Disturbed Sample**		= **Silt**	
				= **Clay**	
				= **Decomposed Rock**	

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**						36K 0686302 UTM 8235950	
LOCATION	**:**		**CHIKWAWA**						SURVEYED BY:	**E. KACHALE**
GROUND ELEV:			**-**						LOGGED BY:	**J. MASEYA**
GROUND WATER LEV:									DATE:	**4/5/2016**
BORE HOLE NO.:			**7**							
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**	
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN**	**IN**	**IN**	**VALUE**	**OF**	**REMARKS**
					150mm	**150mm**	**150mm**	**300mm**	**MATERIAL**	
	0.00									
		--*-*-*-*								
			0.82						Loose dark brown gravely sandy silty CLAY	
	1.00	*-*-*-*-*-*								
			1.37						Firm light brown sandy silt mixed with	
									weathered ROCK	
		--*-*-*-*	1.50	SPT	15	10	8	18		
		--*-*-*-*								
	2.00		2.00						Firm yellowish brown sandy SILT	
		--*-*-*-*								
	3.00	*-*-*-*-*-*	3.00	SPT	15	17	18	35		
		--*-*-*-*								
		--*-*-*-*	3.45						Firm light brown clayey silty SAND with	
		--*-*-*-*							some cables and bounders	**END OF B.H.**

UD	**=**	**Undisturbed Sample**	*-*-*-*-*	**= Sand**	
N	**=**	**SPT N-Value**		**= Gravel**	
D	**=**	**Disturbed Sample**		**= Silt**	
				= Clay	
				= Decomposed Rock	

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**						36K 0686844 UTM8233600		
LOCATION	**:**		**CHIKWAWA**						SURVEYED BY:		**E. KACHALE**
GROUND ELEV:			**-**						LOGGED BY:		**J. MASEYA**
GROUND WATER LEV:									DATE:		**4/6/2016**
BORE HOLE NO.:			**7a**								
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**		
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN**	**IN**	**IN**	**VALUE**	**OF**		**REMARKS**
					150mm	**150mm**	**150mm**	**300mm**	**MATERIAL**		
	0.00	*-*-*-*-*-*-*									
			0.30						Very loose dark brown sandy SILT		
	1.00										
			1.50	SPT	17	23	26	49			
	2.00										
			2.35						Loose dark grey micaceous decompose		70mm penetr
			2.40	CPT	46	55++			ROCK		
	3.00		2.69						Dense dark grey micaceous weathered		
									ROCK		**END OF BH**

UD	=	**Undisturbed Sample**	*-*-*-*-*-	= **Sand**	
N	=	**SPT N-Value**		= **Gravel**	
D	=	**Disturbed Sample**		= **Silt**	
				= **Clay**	
				= **Decomposed Rock**	

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**						36K 0688127 TUM 82.8371	
LOCATION	**:**		**CHIKWAWA**						SURVEYED BY:	**E. KACHALE**
GROUND ELEV:			**-**						LOGGED BY:	**J. MASEYA**
GROUND WATER LEV:									DATE:	**4/6/2016**
BORE HOLE :			**9**							
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**	
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN**	**IN**	**IN**	**VALUE**	**OF**	**REMARKS**
					150mm	**150mm**	**150mm**	**300mm**	**MATERIAL**	
	0.00									
			0.54						Firm dark brown silty CLAY	
	1.00									
			1.50	**SPT**	8	9	9	18		
			1.99						Firm greyish brown weathered ROCK	
	2.00									
	3.00		3.00	SPT	55++				Dense yellowish brown decomposed	**No penetr**
									ROCK	**END OF BH**

UD	**=**	**Undisturbed Sample**	*-*-*-*-*	**= Sand**	
N	**=**	**SPT N-Value**		**= Gravel**	
D	**=**	**Disturbed Sample**		**= Silt**	
				= Clay	
				= Decomposed Rock	

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT	:	LOWERSHIRE VALLEY IRRIGATION									
LOCATION	:	CHIKWAWA							SURVEYED BY:		E. KACHALE
GROUND ELEV.:		-							LOGGED BY:		J. MASEYA
GROUND WATER LEV:		-							DATE:		3/22/2016
BORE HOLE NO.		10		AUGERING POSITIONS							
ELEV. (m)	DEPTH (m)	GRAPHIC	DEPTH (m)	DEPTH (m)	SAMPLE TYPE	NUMBER OF BLOWS IN 150mm	IN 150mm	IN 150mm	SPT N VALUE 300mm	DESCRIPTION OF MATERIAL	REMARKS
	0.00										
				0.40						Loose sandy brown sandy SILT	
	0.50										
	1.00										
	1.50										
			1.65							Loose reddish brown silty CLAY	
	2.00										
	2.50										
	3.00		3.00							Firm greyish brown sandy silty CLAY	END OF BH

UD	=	Undisturbed Sample	*-*-*-*-*	=	Sand
N	=	SPT N-Value		=	Gravel
D	=	Disturbed Sample		=	Silt
				=	Clay
				=	Decomposed Rock

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT	:	LOWERSHIRE VALLEY IRRIGATION			
LOCATION	:	CHIKWAWA	SURVEYED BY:		E. KACHALE
GROUND ELEV.		-	LOGGED BY:		J. MASEYA
GROUND WATER LEV:		-	DATE:		3/22/2016
BORE HOLE NO.:		11			

ELEV. (m)	DEPTH (m)	GRAPHIC	DEPTH (m)	DEPTH (m)	SAMPLE TYPE	NUMBER OF BLOWS IN 150mm	IN 150mm	IN 150mm	SPT N VALUE 300mm	DESCRIPTION OF MATERIAL	REMARKS
	0.00										
	0.50										
			0.95							Loose greyish brown SAND	
	1.00										
	1.50										
			1.84							Loose darkish brown clayey SILT	
	2.00										
	2.50										
	3.00										
			3.00							Firm brown sandy silty CLAY	

UD	=	Undisturbed Sample	= Sand
N	=	SPT N-Value	= Gravel
D	=	Disturbed Sample	= Silt
			= Clay
			= Decomposed Rock

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**						36K 0685873 UTM 8224065		
LOCATION	**:**		**CHIKWAWA**						SURVEYED BY:		**E. KACHALE**
GROUND ELEV:			**-**						LOGGED BY:		**J. MASEYA**
GROUND WATER LEV:									DATE:		**3/28/2016**
BORE HOLE NO.:			**12**								
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**		
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN 150mm**	**IN 150mm**	**IN 150mm**	**VALUE 300mm**	**OF MATERIAL**		**REMARKS**
	0.00										
		--*-*-*-*	0.41						Loose dark brown clayey sandy SILT		
									Firm dark brown sandy silty CLAY with		
			0.52						some particles of weathered ROCK		
	1.00		0.85						Dense sandy silty CLAY quartz GRAVEL		
			1.35						Moltted decomposed ROCK		
			1.50	SPT	17	23	26	49			
	2.00										
			2.80						Hard greyish brown weathered ROCK		**END OF BH**
	3.00										

UD	**=**	**Undisturbed Sample**	*-*-*-*-*	**= Sand**	
N	**=**	**SPT N-Value**		**= Gravel**	
D	**=**	**Disturbed Sample**		**= Silt**	
				= Clay	
				= Decomposed Rock	

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**						36K 0585726 UTM 8222502	
LOCATION	**:**		**CHIKWAWA**						SURVEYED BY:	**E. KACHALE**
GROUND ELEV:			**-**						LOGGED BY:	**J. MASEYA**
GROUND WATER LEV:									DATE:	**3/27/2016**
BORE HOLE	**:**		**13**							
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**	
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN**	**IN**	**IN**	**VALUE**	**OF**	**REMARKS**
					150mm	**150mm**	**150mm**	**300mm**	**MATERIAL**	
	0.00	*-*-*-*-*-*-*	0.63						Firm dark brown sandy silty CLAY	
			1.50	**SPT**	12	22	34	56		
			1.80						Firm moltted decomposed ROCK	
	2.00									
			3.00	SPT	55++					20mm penetr
			3.20						Dense yellowish brown decomposed	
									ROCK	**END OF BH**

UD	**=**	**Undisturbed Sample**	*-*-*-*-*-	**=**	**Sand**
N	**=**	**SPT N-Value**		**=**	**Gravel**
D	**=**	**Disturbed Sample**		**=**	**Silt**
				=	**Clay**
				=	**Decomposed Rock**

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**								
LOCATION	**:**		**CHIKWAWA**							SURVEYED BY:	**E. KACHALE**
GROUND ELEV:			-							LOGGED BY:	**J. MASEYA**
GROUND WATER LEV:										DATE:	**3/27/2016**
BORE HOLE NO.:			**14**								
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**		
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN**	**IN**	**IN**	**VALUE**	**OF**		**REMARKS**
					150mm	**150mm**	**150mm**	**300mm**	**MATERIAL**		
	0.00										
			0.30						Firm dark brown sandy silty CLAY		
		--*-*-*-*-*									
			0.60						Dense light brown sandy silty CLAY		
	1.00								with some pebbles		
			1.50	**SPT**	55+						80mm penetr
	2.00										
			2.30						Hard greyish brown weathered ROCK		**END OF BH**

UD	**=**	**Undisturbed Sample**	*-*-*-*-*	**= Sand**	
N	**=**	**SPT N-Value**		**= Gravel**	
D	**=**	**Disturbed Sample**		**= Silt**	
				= Clay	
				= Decomposed Rock	

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**						36K 0685374 UTM 8217814	
LOCATION	**:**		**CHIKWAWA**						SURVEYED BY:	**E. KACHALE**
GROUND ELEV:			**-**						LOGGED BY:	**J. MASEYA**
GROUND WATER LEV:									DATE:	**3/25/2016**
BORE HOLE NO.:			**15**							
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**	
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN**	**IN**	**IN**	**VALUE**	**OF**	**REMARKS**
					150mm	**150mm**	**150mm**	**300mm**	**MATERIAL**	
	0.00									
			0.30						Loose darkish brown silty CLAY	Top soil
	1.00									
			1.50	SPT	8	10	18	28		
	2.00									
			2.50						Firm whitish grey decomposed ROCK	
	3.00		3.00	CPT	26	52	55	107		
			3.45						Dense yellowish brown weathered ROCK	**END OF BH**

UD	**=**	**Undisturbed Sample**	*-*-*-*-*	**= Sand**	
N	**=**	**SPT N-Value**		**= Gravel**	
D	**=**	**Disturbed Sample**		**= Silt**	
				= Clay	
				= Decomposed Rock	

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**								
LOCATION	**:**		**CHIKWAWA**						SURVEYED BY:		**E. KACHALE**
GROUND ELEV:			-						LOGGED BY:		**J. MASEYA**
GROUND WATER LEV:									DATE:		**3/24/2016**
BORE HOLE NO.:			**16**								
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**		
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN**	**IN**	**IN**	**VALUE**	**OF**		**REMARKS**
					150mm	**150mm**	**150mm**	**300mm**	**MATERIAL**		
	0.00	*-*-*-*-*-*									
		--*-*-*-*							Very loose darkish brown sandy silty		
									CLAY		
			0.78								
	1.00										
		--*-*-*-*									
			1.30						Loose dark brown clayey sandy SILT		
		--*-*-*-*									
		--*-*-*-*									
		--*-*-*-*	1.50	SPT	6	5	3	8			
	2.00	*-*-*-*-*-*									
		--*-*-*-*									
		--*-*-*-*									
		--*-*-*-*	2.70						Ligh brown fine SAND		
		--*-*-*-*									
		--*-*-*-*									
	3.00	*-*-*-*-*-*	3.00	SPT	8	6	9	15			
		--*-*-*-*									
		--*-*-*-*									
		--*-*-*-*	3.45						Greyish brown medium to coarse SAND		**END OF BH**

UD	**=**	**Undisturbed Sample**	*-*-*-*-*	**= Sand**	
N	**=**	**SPT N-Value**		**= Gravel**	
D	**=**	**Disturbed Sample**		**= Silt**	
				= Clay	
				= Decomposed Rock	

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT	:	LOWERSHIRE VALLEY IRRIGATION									
LOCATION	:	CHIKWAWA							SURVEYED BY:		E. KACHALE
GROUND ELEV.:		-							LOGGED BY:		J. MASEYA
GROUND WATER LEV:		-							DATE:		3/22/2016
BORE HOLE NO.:		16a									
ELEV.	DEPTH		DEPTH	DEPTH	SAMPLE	NUMBER OF BLOWS			SPT N	DESCRIPTION	
(m)	(m)	GRAPHIC	(m)	(m)	TYPE	IN	IN	IN	VALUE	OF	REMARKS
						150mm	150mm	150mm	300mm	MATERIAL	
	0.00										
	1.00		1.10							Loose dark brown sandy SILT	
	2.00		2.10							Firm brown sandy silty CLAY	
	3.00										
	4.00										
	5.00										
	6.00										

UD	=	Undisturbed Sample		=	Sand
N	=	SPT N-Value		=	Gravel
D	=	Disturbed Sample		=	Silt
				=	Clay
				=	Decomposed Rock

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT	:	LOWERSHIRE VALLEY IRRIGATION			
LOCATION	:	CHIKWAWA	SURVEYED BY:		E. KACHALE
GROUND ELEV.:		-	LOGGED BY:		J. MASEYA
GROUND WATER LEV:		-	DATE:		3/22/2016
BORE HOLE NO.:		17			

ELEV. (m)	DEPTH (m)	GRAPHIC	DEPTH (m)	DEPTH (m)	SAMPLE TYPE	NUMBER OF BLOWS IN 150mm	IN 150mm	IN 150mm	SPT N VALUE 300mm	DESCRIPTION OF MATERIAL	REMARKS
	0.00	*-*-*-*-*-*-*									
		--*-*-*-*-*									
	1.00	*-*-*-*-*-*-*									
		--*-*-*-*-*									
		--*-*-*-*-*									
	2.00										
										Very loose greuish brown sand	
	3.00		3.00							clayey SILT	
	4.00										
	5.00										
	6.00										

UD	=	Undisturbed Sample	*-*-*-*-* = Sand
N	=	SPT N-Value	= Gravel
D	=	Disturbed Sample	= Silt
			= Clay
			= Decomposed Rock

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MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**								
LOCATION	**:**		**CHIKWAWA**							SURVEYED BY:	**E. KACHALE**
GROUND ELEV:			**-**							LOGGED BY:	**J. MASEYA**
GROUND WATER LEV:										DATE:	**3/24/2016**
BORE HOLE NO.:			**18**								
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**		
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN 150mm**	**IN 150mm**	**IN 150mm**	**VALUE 300mm**	**OF MATERIAL**		**REMARKS**
	0.00	*-*-*-*-*-*									
		--*-*-*-*	0.15						Very loose dark brown clayey sandy SILTY		
			0.30						Loose dark brown sandy silty CLAY		
	1.00		0.70						Firm light brown silt CLAY		
		--*-*-*-*									
		--*-*-*-*									
		--*-*-*-*	1.50	SPT	6	8	11	19			
		--*-*-*-*									
		--*-*-*-*									
	2.00										
		--*-*-*-*	2.90						Firm dark brown sandy silty CLAY		
	3.00	*-*-*-*-*-*	3.00	SPT	7	7	8	15			
		--*-*-*-*							A band of yellowish brown sandy SILT		
		--*-*-*-*									
		--*-*-*-*									
		--*-*-*-*									
		--*-*-*-*									
	4.00										
			4.50	SPT	5	8	9	17			
	5.00										
			6.00	SPT	6	9	10	19			
	5.60		6.45						Stiff dark brown sandy silty CLAY		**END OF BH**
UD		**=**	**Undisturbed Sample**			*-*-*-*-*	**= Sand**				
N		**=**	**SPT N-Value**				**= Gravel**				
D		**=**	**Disturbed Sample**				**= Silt**				
							= Clay				

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT	:	LOWERSHIRE VALLEY IRRIGATION									
LOCATION	:	CHIKWAWA							SURVEYED BY:		E. KACHALE
GROUND ELEV.:		-							LOGGED BY:		J. MASEYA
GROUND WATER LEV:		-							DATE:		3/22/2016
BORE HOLE NO.:		20									
ELEV.	DEPTH		DEPTH	DEPTH	SAMPLE	NUMBER OF BLOWS			SPT N	DESCRIPTION	
(m)	(m)	GRAPHIC	(m)	(m)	TYPE	IN	IN	IN	VALUE	OF	REMARKS
						150mm	150mm	150mm	300mm	MATERIAL	
	0.00										
	1.00		1.00							Very loose brown sandy SILTY	
	2.00									Loose to firm greyish sandy silty	
			2.10							CLAY	
	3.00		3.00							Firm dark brown sandy silty CLAY	
	4.00										
	5.00										
	6.00										
	7.00										
	8.00										
	9.00										
	10.00										END OF BH

UD	=	Undisturbed Sample	*-*-*-*-*.	=	Sand
N	=	SPT N-Value		=	Gravel
D	=	Disturbed Sample		=	Silt
				=	Clay
				=	Decomposed Rock

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT	:	LOWERSHIRE VALLEY IRRIGATION										
LOCATION	:	CHIKWAWA								SURVEYED BY:		E. KACHALE
GROUND ELEV.:		-								LOGGED BY:		J. MASEYA
GROUND WATER LEV:		-								DATE:		3/22/2016
BORE HOLE NO.:		21										
ELEV.	DEPTH		DEPTH	DEPTH	SAMPLE	NUMBER OF BLOWS			SPT N	DESCRIPTION		
(m)	(m)	GRAPHIC	(m)	(m)	TYPE	IN	IN	IN	VALUE	OF		REMARKS
						150mm	150mm	150mm	300mm	MATERIAL		
	0.00											
	0.50											
			0.80							Very loose greyish sandy SILT		
	1.00											
	1.50											
	2.00											
			2.20							firm brown sandy silty CLAY		END OF BH
	2.50											

UD	=	Undisturbed Sample	*-*-*-*	=	Sand
N	=	SPT N-Value		=	Gravel
D	=	Disturbed Sample		=	Silt
				=	Clay
				=	Decomposed Rock

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**							
LOCATION	**:**		**CHIKWAWA**						SURVEYED BY:	**E. KACHALE**
GROUND ELEV:			**-**						LOGGED BY:	**J. MASEYA**
GROUND WATER LEV:									DATE:	**3/24/2016**
BORE HOLE NO.:			**22**							
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**	
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN**	**IN**	**IN**	**VALUE**	**OF**	**REMARKS**
					150mm	**150mm**	**150mm**	**300mm**	**MATERIAL**	
	0.00									
									Loose darkish brown silty SAND	
		--*-*-*-*								
		--*-*-*-*	0.63							
	1.00	*-*-*-*-*-*								
		--*-*-*-*								
									Filrm light brown sand silty CLAY	
			1.95							
	2.00									
		--*-*-*-*								
		--*-*-*-*								
	3.00	*-*-*-*-*-*	3.00	SPT	8	10	12	22	Firm dark brown silty SAND	**END OF BH**

UD	**=**	**Undisturbed Sample**	*-*-*-*-*	**=**	**Sand**
N	**=**	**SPT N-Value**		**=**	**Gravel**
D	**=**	**Disturbed Sample**		**=**	**Silt**
				=	**Clay**
				=	**Decomposed Rock**

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**							
LOCATION	**:**		**CHIKWAWA**						SURVEYED BY:	**E. KACHALE**
GROUND ELEV:			-						LOGGED BY:	**J. MASEYA**
GROUND WATER LEV:			-						DATE:	**3/22/2016**
BORE HOLE NO.:			**23**							
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**	
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN**	**IN**	**IN**	**VALUE**	**OF**	**REMARKS**
					150mm	**150mm**	**150mm**	**300mm**	**MATERIAL**	
	0.00		0.25						Loose dark brown sandy silty CLAY	
			0.46						Firm dark brown sandy silty CLAY	
			0.88						Light Brown Sandy Silty CLAY	
				STP	3	3	4	7		
	1.90									
			1.95						Light brown weathered ROCK	
			2.81	SPT	36	55++			highly weathered ROCK	
	3.00									
										END OF BH

UD	=	**Undisturbed Sample**	*-*-*-*	=	**Sand**
N	=	**SPT N-Value**		=	**Gravel**
D	=	**Disturbed Sample**		=	**Silt**
				=	**Clay**
				=	**Decomposed Rock**

MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE
MATERIALS LABORATORY
DRILLING HOLE LOG

PROJECT			**LOWERSHIRE VALLEY IRRIGATION**							
LOCATION	**:**		**CHIKWAWA**						SURVEYED BY:	**E. KACHALE**
GROUND ELEV:			**-**						LOGGED BY:	**J. MASEYA**
GROUND WATER LEV:			**-**						DATE:	**3/22/2016**
BORE HOLE NO.:			**24**							
ELEV	**DEPTH**		**DEPTH**	**SAMPLE**	**NUMBER OF BLOWS**			**SPT N**	**DESCRIPTION**	
(m)	**(m)**	**GRAPHIC**	**(m)**	**TYPE**	**IN**	**IN**	**IN**	**VALUE**	**OF**	**REMARKS**
					150mm	**150mm**	**150mm**	**300mm**	**MATERIAL**	
	0.00		0.95						Very loose dark grey silty sandy CLAY	
			1.50	**STP**	3	3	4	7		
	1.90									
	2.00									
			2.60						Loose dark brown silty CLAY	
	3.00		3.00	SPT	3	3	4	7		
									Loose light brown SILT	**END OF BH**

UD	**=**	**Undisturbed Sample**	*-*-*-*-*-	**=**	**Sand**
N	**=**	**SPT N-Value**		**=**	**Gravel**
D	**=**	**Disturbed Sample**		**=**	**Silt**
				=	**Clay**
				=	**Decomposed Rock**

Appendix E. Test Results (Boreholes)

MINISTRY OF TRANSPORT AND PUBLIC WORKS

LABORATORY TEST RESULTS

CLIENT : KRC-DASAN AND GK WORKS

PROJECT : LOWERSHIRE VALLEY IRRIGATION **LOCATION: CHIKWAWA**

BOREHOLE NO	SAMPLE NO.	DEPTH (m)	PARTICLE SIZE DISTRIB % PASSING SIEVE SIZE (26.5	19.0	13.2	9.5	4.75	2.36	.600	.425	.300	.150	.075	ATTERBERG LIMITS L.L	P.I.	CLASSIFICATION	B.S HEAVY COMPACTION MDD kg/m3	O.M.C %	C.B.R. % % COMPACTION 95	98	REMARKS COORDNATES
7a	1	**0.00-0.30**	**100**	83	79	74	61	46	31	29	28	25	23	41	20	A-2-7(1)					
	2	0.30-2.35			100	99	97	89	46	39	30	18	14	20	10	A-2-4(0)					
	3	2.35-2.65		100	99	96	61	39	16	13	11	7	5	N	P	A-1-a(0)					
A	1	0.00-0.40	100	99	99	99	99	98	85	72	62	29	20	N	P	A-2-4(0)					
	2	0.40-1.30	100	96	95	95	94	91	77	69	59	32	22	21	9	A-2-4(0)					
1	1	0.00-0.75				100	99	97	74	64	52	30	22	N	P	A-2-4(0)					
	2	0.75-1.90		100	99	97	92	85	57	47	39	24	19	29	15	A-2-6(0)					
	3	1.90-3.25			100	99	99	96	74	62	48	27	21	23	10	A-2-6(0)					
	4	3.25-3.47		100	99	98	92	84	57	45	38	17	12	N	P	A-2-4(0)					
	5	3.47-5.20	100	66	84	62	53	38	23	19	16	13	12	N	P	A-2-4(0)					
	6	5.20-6.47	100	78	74	70	63	54	26	19	13	5	3	N	P	A-1-b(0)					
2	1	0.00-0.50					100	98	74	64	53	32	25	N	P	A-2-4(0)					
	2	0.50-1.97			100	99	95	89	61	53	44	29	22	28	18	A-2-6(0)					
	3	1.97-2.96	100	81	79	79	77	65	37	32	26	17	13	26	12	A-2-6(0)					
	4	2.96-5.22		100	99	99	96	89	66	59	49	27	19	N	P	A-2-4(0)					
	5	5.22-5.50				100	99	98	89	30	25	19	4	N	P	A-1-b(0)					
	6	5.50-6.50				100	99	91	36	27	18	7	4	N	P	A-1-b(0)					

MINISTRY OF TRANSPORT AND PUBLIC WORKS
LABORATORY TEST RESULTS

CLIENT : KRC-DASAN AND GK WORKS

PROJECT : LOWERSHIRE VALLEY IRRIGATION LOCATION: CHIKWAWA

BOREHOLE NO	SAMPLE NO.	DEPTH (m)	PARTICLE SIZE DISTRIB % PASSING SIEVE SIZE (26.5	19.0	13.2	9.5	4.75	2.36	.600	.425	.300	.150	.075	ATTERBERG LIMITS L.L	P.I.	CLASSIFICATION	B.S HEAVY COMPACTION MDD kg/m3	O.M.C %	C.B.R. % % COMPACTION 95	98	REMARKS COORDNATES
3	1	**0.00-0.20**	**100**	99	96	95	89	82	65	58	48	21	13	N	P	A-2-4(0)					
	2	0.20-0.55	100	98	95	93	88	82	64	56	47	28	20	N	P	A-2-4(0)					
	3	0.55-1.25		100	91	89	82	77	62	57	48	32	26	32	19	A-2-6(0)					
	4	1.25-1.45	100	77	74	72	70	66	54	50	44	29	23	N	P	A-1-b(0)					
	5	1.45-2.68			100	99	91	81	52	45	35	24	18	27	14	A-2-6(0)					
40	6	2.68-5.45	100	74	63	45	16	4	2	2	2	2	2	N	P	A-1-b(0)					
	7	5.45-6.25	100	98	98	97	95	91	72	62	50	25	17	N	P	A-2-4(0)					
	8	6.25-7.50		100	99	96	88	77	50	42	31	14	7	N	P	A-2-4(0)					
	9	7.50-8.75		100	98	96	90	77	37	30	22	10	6	N	P	A-1-b(0)					
	10	8.75-9.70	100	95	93	92	85	72	30	23	17	7	4	N	P	A-1-b(0)					
4	1	0.00-0.64	100	96	91	86	79	71	55	46	34	20	15	N	P	A-1-b(0)					
	2	0.64-0.95	100	95	93	92	87	81	66	57	56	24	18	N	P	A-2-4(0)					
	3	0.95-1.75	100	94	89	89	88	85	68	62	50	29	21	N	P	A-2-4(0)					
	4	1.75-3.02	100	94	91	89	87	80	61	54	48	28	19	31	11	A-2-6(0)					
5	1	0.00-0.85	100	83	82	80	77	72	55	49	42	26	19	N	P	A-1-b(0)					
	2	0.85-2.82			100	99	98	95	78	69	58	31	24	N	P	A-2-4(0)					
	3	2.82-3.45				100	98	96	85	78	65	37	30	N	P	A-2-4(0)					

MINISTRY OF TRANSPORT AND PUBLIC WORKS
LABORATORY TEST RESULTS

CLIENT : KRC-DASAN AND GK WORKS

PROJECT : LOWERSHIRE VALLEY IRRIGATION LOCATION: CHIKWAWA

BOREHOLE NO	SAMPLE NO.	DEPTH (m)	PARTICLE SIZE DISTRIB % PASSING SIEVE SIZE (26.5	19.0	13.2	9.5	4.75	2.36	.600	.425	.300	.150	.075	ATTERBERG LIMITS L.L	P.I.	CLASSIFICATION	B.S HEAVY COMPACTION MDD kg/m3	O.M.C %	C.B.R. % % COMPACTION 95	98	REMARKS COORDNATES
6	1	**0.00-0.61**	**100**	96	96	96	94	92	82	75	65	34	25	N	P	A-2-4(0)					
	2	0.61-1.90			100	98	95	91	75	66	48	29	24	30	13	A-2-6(0)					
	3	1.90-2.56		100	98	95	90	84	68	61	52	29	21	22	6	A-2-4(0)					
	4	2.56-3.45	100	99	99	98	96	87	81	66	32	28	23	20	11	A-2-6(0)					
7	1	0.00-0.82		100	99	97	88	78	58	51	43	27	17	18	7	A-2-4(0)					
	2	0.82-1.37		100	99	98	92	83	58	53	44	28	21	26	13	A-2-6(0)					
	3	1.37-2.00	100	81	79	79	76	73	59	55	48	30	22	24	5	A-2-4(0)					
	4	2.00-3.45	100	64	63	61	55	50	38	34	29	17	12	28	8	A-2-4(0)					
9	1	0.00-0.54				100	97	95	89	85	78	52	41	35	16	A-6(2)					
	2	0..54-1.99			100	99	93	83	65	61	56	41	34	42	22	A-2-7(2)					
	3	1.99-3.00			100	99	95	87	64	56	47	28	22	37	15	A-2-6(0)					

MINISTRY OF TRANSPORT AND PUBLIC WORKS
LABORATORY TEST RESULTS

CLIENT : KRC-DASAN AND GK WORKS

PROJECT : LOWERSHIRE VALLEY IRRIGATION **LOCATION: CHIKWAWA**

BOREHOLE NO	SAMPLE NO.	DEPTH (m)	PARTICLE SIZE DISTRIB % PASSING SIEVE SIZE (26.5	19.0	13.2	9.5	4.75	2.36	.600	.425	.300	.150	.075	ATTERBERG LIMITS L.L	P.I.	CLASSIFICATION	B.S HEAVY COMPACTION MDD kg/m3	O.M.C %	C.B.R. % % COMPACTION 95	98	REMARKS COORDNATES
12	1	**0.00-0.41**			100	99	98	96	82	75	65	38	28	N	P	A-2-4(0)					
	2	0.41-0.52	100	90	88	82	71	65	58	39	34	26	21	32	12	A-2-6(0)					
	3	0.52-0.85	100	92	87	83	69	63	60	46	41	29	25	38	21	A-2-6(1)					
	4	0.85-1.35	100	93	89	84	71	62	59	48	40	35	30	41	8	A-2-5(0)					
	5	1.35-2.80	100	97	96	93	85	71	39	34	29	20	15	N	P	A-1-b(0)					
13	1	0.00-0.63				100	99	98	88	84	76	52	42	36	24	A-6(1)					
	2	0.63-1.80	100	98	96	93	90	83	78	59	48	39	30	29	14	A-2-6(1)					
	3	1.80-3.20	100	99	99	98	97	96	86	76	63	37	25	N	P	A-2-4(0)					
14	1	0.00-0.30			100	100	98	95	86	82	76	53	41	30	11	A-6(0)					
	2	0.30-060		100	94	91	80	69	56	51	45	32	26	16	7	A-2-4(0)					
	3	0.60-2.30	100	90	84	79	73	66	51	46	39	24	19	23	10	A-2-4(0)					
15	1	0.00-0.30	100	90	89	86	75	63	59	52	41	34	29	30	15	A-2-6(1)					
	2	0.30-2.50	100	91	90	81	70	65	58	47	39	33	26	32	16	A-2-6(1)					
	3	2.50-3.45			100	98	93	86	68	61	51	35	28	35	14	A-2-6(1)					
16	1	0.00-0.78		100	99	98	96	95	94	91	85	62	52	34	23	A-6(8)					
	2	0.78-1.30				100	99	98	97	93	86	58	47	35	16	A-6(5)					
	3	1.30-2.70					100	99	98	95	89	51	40	N	P	A-4(0)					
	4	2.70-3.45			100	99	96	94	91	70	47	23	17	N	P	A-2-4(0)					

MINISTRY OF TRANSPORT AND PUBLIC WORKS
LABORATORY TEST RESULTS

CLIENT : KRC-DASAN AND GK WORKS

PROJECT : LOWERSHIRE VALLEY IRRIGATION **LOCATION: CHIKWAWA**

BOREHOLE NO	SAMPLE NO.	DEPTH (m)	PARTICLE SIZE DISTRIB % PASSING SIEVE SIZE (26.5	19.0	13.2	9.5	4.75	2.36	.600	.425	.300	.150	.075	ATTERBERG LIMITS L.L	P.I.	CLASSIFICATION	B.S HEAVY COMPACTION MDD kg/m3	O.M.C %	C.B.R. % % COMPACTION 95	98	REMARKS COORDNATES
18	1	0.00-015	100	89	83	70	63	49	40	34	26	19	19	N	P	A-1-b(0)					
	2	0.15-0.30					100	99	97	91	88	55	44	27	11	A--6(2)					
	3	0.30-0.70					100	99	97	95	90	62	50	28	15	A-6(4)					
	4	0.70-2.90				100	99	99	96	94	91	65	53	38	19	A-6(7)					
	5	2.90-3.00				100	99	98	97	96	94	67	55	50	23	A--7-6(8)					
73	6	3.00-6.45			100	98	96	90	86	80	65	57	49	49	25	A-7-6(8)					
22	1	0.00-0.63				100	95	90	86	63	45	23	16	N	P	A-2-4(0)					
	2	0.62-195						100	86	73	59	42	36	29	21	A-6(2)					
	3	1.95-3.00					100	98	70	55	39	24	19	N	P	A-2-4(0)					
23	1	0.00-0.25	100	96	96	95	93	91	77	73	67	51	42	29	13	A-6(2)					
	2	0.25-0.46	100	93	90	85	76	71	64	59	55	46	38	41	23	A-2-6(4)					
	3	0.46-0.88	100	95	95	94	89	84	59	55	50	43	38	35	14	A-6(2)					
	4	0.88-1.38			100	99	96	91	52	46	41	31	24	26	13	A-2-6(0)					
	5	1.38-1.95	100	85	77	73	66	61	42	38	34	27	22	N	P	A-1-b(0)					
	6	1.95-2.35	100	92	90	88	80	65	21	17	14	8	6	N	P	A-1-b(0)					
24	1	0.00-0.95						100	97	95	91	83	79	N	P	A-4(0)					
	2	.95-2.60						100	97	94	89	79	73	39	18	A-6(10)					
	3	2.60-3.00					100	99	96	94	89	65	55	34	18	A-6(6)					

Appendix F. Gravel Test Results

MINISTRY OF TRANSPORT AND PUBLIC WORKS
LABORATORY TEST RESULTS

CLIENT : KRC-DASAN AND GK WORKS

PROJECT : LOWERSHIRE VALLEY IRRIGATION LOCATION: CHIKWAWA

BOREHOLE NO	SAMPLE NO.	DEPTH (m)	PARTICLE SIZE DISTRIB % PASSING SIEVE SIZE (26.5	19.0	13.2	9.5	4.75	2.36	.600	.425	.300	.150	.075	ATTERBERG LIMITS L.L	P.I.	CLASSIFICATION	B.S HEAVY COMPACTION MDD kg/m3	O.M.C %	C.B.R. % % COMPACTION 95	98	REMARKS COORDNATES
CHIKHAMBA	1		100	95	95	93	86	74	51	49	38	34	31	31	15	A-2-4(0)					
B/PIT	2		100	97	96	92	85	71	48	47	36	32	30	33	17	A-2-6(2)					
	3		100	95	95	93	84	72	52	42	29	29	24	34	17	A-2-6(1)					
	4		100	99	99	96	90	83	68	64	47	42	36	40	23	A-2-6(3)					
	MIXED 5			100	99	98	91	85	69	63	48	48	35	36	18	A-2-6(2)	1980	9.4	23	25	
MOROKO	1		100	94	92	87	72	52	34	31	29	23	20	46	25	A-2-7(1)					
B/PIT	2		1000	91	86	81	61	54	37	34	30	20	16	36	17	A-2-6-(0)					
	3		100	94	91	87	77	63	45	42	37	28	23	38	17	A-2-6(1)					
	4		100	95	94	90	82	73	52	47	42	26	21	29	12	A-2-6(0)					
	MIXED 5		100	96	94	93	89	82	74	89	58	49	40	45	24	A-6(5)	1962	11.9	24	33	
KALUMPHA	1		100	86	71	65	52	46	35	28	26	19	18	30	7	A-2-4(0)					
B/PIT	2		100	73	73	67	55	43	28	26	23	17	13	N	P	A-1-b(0)					
	3		100	84	80	70	61	56	49	40	37	30	25	30	15	A-2-6(0)					
	4		100	89	76	64	53	46	38	35	30	26	24	28	14	A-2-6(0)					
	MIXED 5		100	88	78	68	57	49	41	36	32	30	27	39	22	A-2-6(2)	2065	10.9	48	65	
NAMACHA	1		100	90	89	76	68	50	39	35	30	23	20	44	29	A-2-6(1)					
B/PIT	2		100	96	93	89	76	62	38	34	31	22	18	39	10	A-2-4(0)					
	3		100	96	93	89	76	62	38	34	31	22	18	42	9	A-2-4(0)					
	4		100	89	87	86	79	63	43	38	34	25	19	40	24	A-2-6(1)					
	MIXED 5		100	82	77	66	41	40	35	28	23	29	17	30	16	A-2-6(0)	1995	10.7	28	40	

MINISTRY OF TRANSPORT AND PUBLIC WORKS
LABORATORY TEST RESULTS

CLIENT : KRC-DASAN AND GK WORKS

PROJECT : LOWERSHIRE VALLEY IRRIGATION **LOCATION: CHIKWAWA**

BOREHOLE NO	SAMPLE NO.	DEPTH (m)	PARTICLE SIZE DISTRIB % PASSING SIEVE SIZE (26.5	19.0	13.2	9.5	4.75	2.36	.600	.425	.300	.150	.075	ATTERBERG LIMITS L.L	P.I.	CLASSIFICATION	B.S HEAVY COMPACTION MDD kg/m3	O.M.C %	C.B.R. % % COMPACTION 95	98	REMARKS COORDNATES
TOMALI	1		100	78	67	58	39	30	18	16	14	9	6	33	10	A-2-4(0)					
B/PIT	2		100	97	93	89	80	66	52	49	46	36	30	25	13	A-2-6(1)					
	3		100	89	82	71	59	46	39	32	24	18	15	30	6	A-2-4(0)					
	4		100	99	97	94	81	62	38	34	31	23	19	31	14	A-2-6(0)					
	MIXED 5		100	79	70	54	28	15	8	7	7	5	3	35	21	A-2-6(0)	2030	10.4	60	76	
NYAIKA	1		100	88	85	77	64	48	34	32	30	25	22	42	25	A-2-7(1)					
B/PIT	2		1000	94	91	82	66	50	34	33	31	28	25	48	24	A-2-7(1)					
	3		100	85	76	67	51	40	28	26	25	21	18	45	22	A-2-7(0)					
	4		100	89	80	80	59	43	31	29	28	26	22	26	17	A-2-6(0)					
	MIXED 5		100	94	85	78	63	44	35	34	33	30	27	49	26	A-2-7(2)	1925	12.8	25	36	
SIBAHE	1		100	89	89	84	39	16	8	7	6	5	5	N	P	A-1-a(0)					
B/PIT	2			100	97	90	64	47	21	18	14	9	6	N	P	A-1-a(0)					
	3		100	89	89	84	73	54	20	17	14	11	9	N	P	A-1-a(0)					
	4		100	89	78	72	62	52	28	24	19	13	9	N	P	A-1-a(0)					
	MIXED 5		100	79	73	68	56	39	30	26	19	14	11	N	P	A-1-a(0)	2025	9.2	40	56	
NYAMITHUTHU	1		100	90	73	53	21	5	3	0	0	0	0	N	P	A-1-a(0)					
B/PIT	2		100	91	73	57	41	40	39	38	32	24	15	33	10	A-1-a(0)					
	3		100	94	81	75	50	28	9	8	6	5	4	N	P	A-1-a(0)					
	4		100	98	96	90	68	36	10	9	8	7	6	N	P	A-1-a(0)					
	MIXED 5		100	78	69	48	39	35	30	24	23	19	18	27	9	A-1-a(0)	2090	8.4	34	48	

Appendix G. Borehole Unit Weight & NMC

	MINISTRY OF TRANSPORT & PUBLIC WORKS			
	CENTRAL MATERIAL LABORATORY			
	BH - NMC & UNIT WEIGHT TEST			
BH NO	**DESCRPTION**		**NMC %**	**UNIT WEGHT**
BH 1	Dark brown sandy silty CLAY	AA 126.96g - 115.0	10.4	1017g/mm³
BH 2	Dark brown sandy silty CLAY	24=176.57-162.0	9.0	1115g/mm³
BH 3	Dark brown silty clay SAND	RR=202.65-175.0	15.8	147.5g/mm³
BH 4	Dark brown sandy silty CLAY	yoy 985g-903g	9.1	180.4g/mm³
BH 5	Light brown silty CLAY	kk 890-815g		1630g/mm³
BH 6	Light brown silty CLAY	f 920-835g	9.2	1170g/mm³
BH 7	Quartz gravel feeder canal	top 970g-902g	7.5	1804g/m³
BH 9	Light brown sandy silty CLAY	to 172-165	4.2	1079g/mm³
BH 12	Light gravel (no unit weight)			
BH 13	Light brown sandy silty CLAY	MDD 850g - 765g	5.5	1122g/mm³
BH 14	Dark brown sandy silty CLAY	PT 401-380		94.0g/mm³
BH 15	Light brown decomposed ROCK	KT 595-550G	8.2	1054g/m³
BH 16	Dark brown sandy silty CLAY	LL 500-444	12.6	1035g/m³
BH 18	Light brown clayey sand SILT	BB 520-489	6.3	1078g/m³
BH 22	Light brown clayey SILT	CL 920-865g	6.4	1114g/m³
BH 23	Light brown decomposed ROCK	KK 1105-945g	16.9	1908g/m³
BH 24	Dark brown sandy SILTY	TI 631-552g	14.4	1103g/m³
BH A	Loose dark brown clayey sitly SAND	LLK 12g -111g	8.1	1304g/m³
BH 7a	Loose dark grey micaceous decomposed ROCK	NO UNIT WEIGHT		

Appendix H. Auguring, Unit Weight & NMC

SHIRE VALLEY IRRIGATION
AUGURING NMC & UNIT
WEIGHT TEST

BH NO	DESCRPTION	AUGURING	NMC %	UNIT WEGHT
BH 5a	No auguring because rock & No unit weight			
BH 8	No Auguring because rock	MP 306.8-279g	9.9	
BH 10	Loose sandy brown sandy SILT	PK 530-495	7.1	1140g/mm³
BH 11	Loose greyish brown SAND	DD 525g-470g	13.8	1420g/mm³
BH 17	Very loose greyish brown sandy clayey SILT	BL 585-535	9.3	1192g/mm³
BH 19	No Auguring (ROCK)			
BH 20	Very loose brown sandy SILT	BG 450-402	11.9	1200g/mm³
BH 21	Very loose greyish sandy SILT	KA 631g -560g	12.7	1420g/mm³
BH 16a	Loose dark brown sandy SILT	BT 97.17-89.1g	9.1	1181g/mm³

Appendix I. Auguring Test Results

MINISTRY OF TRANSPORT AND PUBLIC WORKS

LABORATORY TEST RESULTS

CLIENT : DASAN & KCR AND GK WORKS — AUGERING

PROJECT : SHIRE VALLEY IRRIGATIION — LOCATION: CHIKWAWA

BH			PARTICLE SIZE DISTRIBU										ATTERBERG			TEST				
PIT	SAMPLE	DEPTH	% PASSING SIEVE SIZE (r										LIMIT		CLASSIFICATION	TRIXIAL/BOX SHEAR				REMARKS
																BULK DENS	M/C	C	ϕ	COORDNATES
NO	NO.	(m)	19.0	13.2	9.5	4.75	2.36	.600	.425	.300	.150	.075	L.L	P.I.		kg/m3	%	KN/M2	o	
5a	NO Augering (ROCK)																			
8	NO Augering (ROCK)																			
10		0.00-0.40	63	51	44	39	36	27	21	18	16	13	N	P	A-1-a(0)					
		0.40-1.65		100	87	83	79	66	58	53	42	36	30	15	A-2-6(2)					
		1.65-3.00		100	84	79	74	63	57	50	41	35	28	14	A-2-6(1)					
11		0.00-0.95	100	56	43	39	31	23	18	17	15	13	N	P	A-1-a(0)					
		0.95-1.84	100	58	53	47	40	32	30	29	24	21	N	P	A-1-a(0)					
		1.84-3.00	100	90	88	82	74	69	61	56	47	40	38	19	A-2-6(0)					
17		0.00-3.0	100	57	44	37	30	22	19	18	16	13	N	P	A-1-a(0)					
16a		0.00-1.1	85	58	45	39	33	29	26	22	19	18	N	P	A-1-a(0)					
		1.10-2.1	84	81	73	64	59	56	50	48	43	37	34	17	A-2-6(3)					
20		0.00-1.00	67	54	46	40	36	30	29	23	21	17	N	P	A-1-a(0)					
		1.00-2.10	89	81	73	69	61	50	43	39	33	29	28	13	A-2-6(1)					
		210-3.00	87	82	75	71	59	53	45	41	39	32	30	15	A-2-6(1)					

MINISTRY OF TRANSPORT AND PUBLIC WORKS
LABORATORY TEST RESULTS

CLIENT : DASAN & KCR AND GK WORKS AUGERING

PROJECT : SHIRE VALLEY IRRIGATIION LOCATION: CHIKWAWA

BH			PARTICLE SIZE DISTRIBU										ATTERBERG			TEST				
PIT	SAMPLE	DEPTH	% PASSING SIEVE SIZE (										LIMI		CLASSIF	TRIXIAL/BOX SHEAR				REMARKS
															ICATION	BULK				COORDNATES
																DENS	M/C	C	ϕ	
NO	NO.	(m)	19.0	13.2	9.5	4.75	2.36	.600	.425	.300	.150	.075	L.L	P.I.		kg/m3	%	KN/M2	o	
21		0.00-0.80	69	65	52	46	39	33	27	21	17	13	N	P	A-1-a(0)					
		1.50-2.20	100	89	84	78	71	63	59	52	41	38	32	16	A-2-6(3)					
19	NO AUGERING																			

Appendix J. Permeability Test Results

Permeability (Falling Head) Test

Date:	**5/25/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 1**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**			50.3	cm^2
Sample and Mould			**Condition of Specimen**			**Before Test**	**After Test**
Diameter	cm	10.2	**Weight of Specimen and Mould, M_a**	g		3562	3763
Cross-section Area, A	cm^2	81.7	**Weight of Specimen, M = M_a - m_m**	g		1727	1928
Length, L	cm	11.6	**Wet Density, ρ_t =**	g/cm^3		1822	2034
Volume, V=A*L	cm^3	0.948	**Moisture Content, ω**	%		10.7	25.5
Weight of mould	g	1835	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3		1646	1621
Soil Specific Gravity	Gs	2.478	**Void Ratio, e**			0.506	0.529
			Degree of Saturation, Sr	%		52.4	119.5

		1	2	3
Start time, t_1	sec	8:00:00 AM	8:49:29 AM	10:02:45 AM
End time, t_2	sec	8:49:29 AM	10:02:45 AM	12:28:18 PM
Measuring Period	sec	2969	4396	8733
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	2.41E-03	1.62E-03	8.18E-04
k in average, k_m	cm/sec	1.62E-03		

Permeability (Falling Head) Test

Date:	**6/5/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 2**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**			50.3	cm^2
Sample and Mould			**Condition of Specimen**			**Before Test**	**After Test**
Diameter	cm	10.5	**Weight of Specimen and Mould, M_a**	g		3605	3752
Cross-section Area, A	cm^2	86.6	**Weight of Specimen, M = M_a - m_m**	g		1800	1947
Length, L	cm	11.5	**Wet Density, ρ_t =**	g/cm^3		1899	2054
Volume, V=A*L	cm^3	0.996	**Moisture Content, ω**	%		12.4	22.4
Weight of mould	g	1805	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3		1689	1678
Soil Specific Gravity	Gs	2.256	**Void Ratio, e**			0.467	0.477
			Degree of Saturation, Sr	%		65.8	116.5

		1	2	3
Start time, t_1	sec	7:30:00 AM	9:54:30 AM	12:44:27 PM
End time, t_2	sec	9:54:30 AM	12:44:27 PM	2:57:08 PM
Measuring Period	sec	8670	10197	7961
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	8.24E-04	7.01E-04	8.97E-04
k in average, k_m	cm/sec	8.07E-04		

Permeability (Falling Head) Test

Date:	**6/4/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 3**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**		50.3	cm^2
Sample and Mould			**Condition of Specimen**		**Before Test**	**After Test**
Diameter	cm	10.3	**Weight of Specimen and Mould, M_a**	g	3415	3591
Cross-section Area, A	cm^2	83.3	**Weight of Specimen, M = M_a - m_m**	g	1590	1766
Length, L	cm	11.6	**Wet Density, ρ_t =**	g/cm^3	1677	1863
Volume, V=A*L	cm^3	0.967	**Moisture Content, ω**	%	16.2	28.9
Weight of mould	g	1825	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3	1444	1445
Soil Specific Gravity	Gs	2.287	**Void Ratio, e**		0.717	0.714
			Degree of Saturation, Sr	%	56.0	100.2

		1	**2**	**3**
Start time, t_1	sec	8:00:00 AM	8:55:13 AM	10:03:12 AM
End time, t_2	sec	8:55:13 AM	10:03:12 AM	11:25:52 AM
Measuring Period	sec	3313	4079	4960
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	2.16E-03	1.75E-03	1.44E-03
k in average, k_m	cm/sec		1.78E-03	

Permeability (Falling Head) Test

Date:	**6/2/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 4**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**		50.3	cm^2
Sample and Mould			**Condition of Specimen**		**Before Test**	**After Test**
Diameter	cm	10.2	**Weight of Specimen and Mould, M_a**	g	3698	3875
Cross-section Area, A	cm^2	81.7	**Weight of Specimen, M = M_a - m_m**	g	1818	1995
Length, L	cm	11.5	**Wet Density, ρ_t =**	g/cm^3	1918	2105
Volume, V=A*L	cm^3	0.940	**Moisture Content, ω**	%	9.2	15.2
Weight of mould	g	1880	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3	1756	1827
Soil Specific Gravity	Gs	2.431	**Void Ratio, e**		0.411	0.356
			Degree of Saturation, Sr	%	55.5	105.7

		1	**2**	**3**
Start time, t_1	sec	8:00:00 AM	11:08:55 AM	1:45:43 PM
End time, t_2	sec	11:08:55 AM	1:45:43 PM	3:53:43 PM
Measuring Period	sec	11335	9408	7680
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	6.30E-04	7.59E-04	9.30E-04
k in average, k_m	cm/sec	7.73E-04		

Permeability (Falling Head) Test

Date:	**5/27/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 5**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**			50.3	cm^2
Sample and Mould			**Condition of Specimen**			**Before Test**	**After Test**
Diameter	cm	10.3	**Weight of Specimen and Mould, M_a**	g		3357	3565
Cross-section Area, A	cm^2	83.3	**Weight of Specimen, M = M_a - m_m**	g		1537	1745
Length, L	cm	11.5	**Wet Density, ρ_t =**	g/cm^3		1622	1841
Volume, V=A*L	cm^3	0.958	**Moisture Content, ω**	%		17.3	34.3
Weight of mould	g	1820	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3		1382	1371
Soil Specific Gravity	Gs	2.25	**Void Ratio, e**			0.793	0.808
			Degree of Saturation, Sr	%		54.1	105.2

		1	**2**	**3**
Start time, t_1	sec	8:30:00 AM	12:01:33 PM	3:43:53 PM
End time, t_2	sec	12:01:33 PM	3:43:53 PM	6:29:23 PM
Measuring Period	sec	12693	13340	9930
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	5.63E-04	5.35E-04	7.19E-04
k in average, k_m	cm/sec	6.06E-04		

Permeability (Falling Head) Test

Date:	**5/26/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 6**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**			50.3	cm^2
Sample and Mould			**Condition of Specimen**			**Before Test**	**After Test**
Diameter	cm	10.2	**Weight of Specimen and Mould, M_a**	g		3271	3555
Cross-section Area, A	cm^2	81.7	**Weight of Specimen, M = M_a - m_m**	g		1391	1675
Length, L	cm	11.5	**Wet Density, ρ_t =**	g/cm^3		1468	1767
Volume, V=A*L	cm^3	0.940	**Moisture Content, ω**	%		11.2	41.1
Weight of mould	g	1820	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3		1320	1252
Soil Specific Gravity	Gs	2.25	**Void Ratio, e**			0.878	0.979
			Degree of Saturation, Sr	%		31.6	104.1

		1	**2**	**3**
Start time, t_1	sec	8:30:00 AM	1:26:35 PM	3:02:59 PM
End time, t_2	sec	1:26:35 PM	3:02:59 PM	4:53:00 PM
Measuring Period	sec	17795	5784	6601
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	4.01E-04	1.23E-03	1.08E-03
k in average, k_m	cm/sec	9.06E-04		

Permeability (Falling Head) Test

Date:	**5/29/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 7**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**			50.3	cm^2
Sample and Mould			**Condition of Specimen**			**Before Test**	**After Test**
Diameter	cm	10.2	**Weight of Specimen and Mould, M_a**	g		3344	3564
Cross-section Area, A	cm^2	81.7	**Weight of Specimen, M = $M_a - m_m$**	g		1494	1714
Length, L	cm	11.6	**Wet Density, ρ_t =**	g/cm^3		1576	1808
Volume, V=A*L	cm^3	0.948	**Moisture Content, ω**	%		11.6	47.7
Weight of mould	g	1805	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3		1412	1224
Soil Specific Gravity	Gs	2.371	**Void Ratio, e**			0.755	1.024
			Degree of Saturation, Sr	%		38.1	115.4

		1	2	3
Start time, t_1	sec	8:00:00 AM	11:10:13 AM	12:45:43 PM
End time, t_2	sec	11:10:13 AM	12:45:43 PM	2:48:43 PM
Measuring Period	sec	11413	5730	7380
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	6.26E-04	1.25E-03	9.68E-04
k in average, k_m	cm/sec	9.47E-04		

Permeability (Falling Head) Test

Date:	**5/30/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 8**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**			50.3	cm^2
Sample and Mould			**Condition of Specimen**			**Before Test**	**After Test**
Diameter	cm	10.33	**Weight of Specimen and Mould, M_a**	g		3296	3600
Cross-section Area, A	cm^2	83.8	**Weight of Specimen, M = $M_a - m_m$**	g		1471	1775
Length, L	cm	11.6	**Wet Density, ρ_t =**	g/cm^3		1552	1873
Volume, V=A*L	cm^3	0.972	**Moisture Content, ω**	%		12.2	34.5
Weight of mould	g	1825	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3		1383	1392
Soil Specific Gravity	Gs	2.36	**Void Ratio, e**			0.792	0.780
			Degree of Saturation, Sr	%		38.2	109.6

		1	**2**	**3**
Start time, t_1	sec	8:00:00 AM	10:09:48 AM	12:32:34 PM
End time, t_2	sec	10:09:48 AM	12:32:34 PM	2:50:54 PM
Measuring Period	sec	7788	8566	8300
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	9.17E-04	8.34E-04	8.61E-04
k in average, k_m	cm/sec	8.71E-04		

Permeability (Falling Head) Test

Date:	**6/3/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 9**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**			50.3	cm^2
Sample and Mould			**Condition of Specimen**			**Before Test**	**After Test**
Diameter	cm	10.3	**Weight of Specimen and Mould, M_a**	g		3551	3740
Cross-section Area, A	cm^2	83.3	**Weight of Specimen, M = $M_a - m_m$**	g		1731	1920
Length, L	cm	11.5	**Wet Density, ρ_t =**	g/cm^3		1826	2026
Volume, V=A*L	cm^3	0.958	**Moisture Content, ω**	%		11.4	29.2
Weight of mould	g	1820	**Dry Density, $\rho_d = \rho_t/(1+\omega/100)$**	g/cm^3		1639	1568
Soil Specific Gravity	Gs	2.329	**Void Ratio, e**			0.512	0.581
			Degree of Saturation, Sr	%		55.2	124.6

		1	**2**	**3**
Start time, t_1	sec	7:30:00	10:11:26	13:40:17
End time, t_2	sec	10:11:26	13:40:17	14:43:29
Measuring Period	sec	9686	12531	3792
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	7.37E-04	5.70E-04	1.88E-03
k in average, k_m	cm/sec	1.06E-03		

Permeability (Falling Head) Test

Date:	**5/24/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 10**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**			50.3	cm^2
Sample and Mould			**Condition of Specimen**			**Before Test**	**After Test**
Diameter	cm	10.5	**Weight of Specimen and Mould, M_a**	g		3656	3831
Cross-section Area, A	cm^2	86.6	**Weight of Specimen, M = $M_a - m_m$**	g		1741	1916
Length, L	cm	11.6	**Wet Density, ρ_t =**	g/cm^3		1837	2021
Volume, V=A*L	cm^3	1.004	**Moisture Content, ω**	%		10.4	19.1
Weight of mould	g	1915	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3		1664	1697
Soil Specific Gravity	Gs	2.42	**Void Ratio, e**			0.489	0.460
			Degree of Saturation, Sr	%		52.7	102.9

		1	**2**	**3**
Start time, t_1	sec	8:00:00 AM	9:18:52 AM	12:04:18 PM
End time, t_2	sec	9:18:52 AM	12:04:18 PM	1:48:54 PM
Measuring Period	sec	4732	9926	6276
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	1.51E-03	7.20E-04	1.14E-03
k in average, k_m	cm/sec	1.12E-03		

Permeability (Falling Head) Test

Date:	**2016-15-23**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 11**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**			50.3	cm^2
Sample and Mould			**Condition of Specimen**			**Before Test**	**After Test**
Diameter	cm	10.3	**Weight of Specimen and Mould, M_a**	g		3529	3663
Cross-section Area, A	cm^2	83.3	**Weight of Specimen, M = M_a - m_m**	g		1704	1838
Length, L	cm	11.6	**Wet Density, ρ_t =**	g/cm^3		1798	1939
Volume, V=A*L	cm^3	0.967	**Moisture Content, ω**	%		18	29.2
Weight of mould	g	1825	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3		1523	1501
Soil Specific Gravity	Gs	2.069	**Void Ratio, e**			0.627	0.651
			Degree of Saturation, Sr	%		71.2	111.1

		1	**2**	**3**
Start time, t_1	sec	8:00:00 AM	9:55:56 AM	12:18:18 PM
End time, t_2	sec	9:55:53 AM	12:18:18 PM	2:16:01 PM
Measuring Period	sec	6953	8542	7063
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	1.03E-03	8.36E-04	1.01E-03
k in average, k_m	cm/sec	9.58E-04		

Permeability (Falling Head) Test

Date:	**5/20/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 12**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**			50.3	cm^2
Sample and Mould			**Condition of Specimen**			**Before Test**	**After Test**
Diameter	cm	10.3	**Weight of Specimen and Mould, M_a**	g		3679	3708
Cross-section Area, A	cm^2	83.3	**Weight of Specimen, M = M_a - m_m**	g		1859	1888
Length, L	cm	11.5	**Wet Density, ρ_t =**	g/cm^3		1961	1992
Volume, V=A*L	cm^3	0.958	**Moisture Content, ω**	%		20.4	30.6
Weight of mould	g	1820	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3		1629	1525
Soil Specific Gravity	Gs	2.299	**Void Ratio, e**			0.521	0.625
			Degree of Saturation, Sr	%		97.0	121.4

		1	**2**	**3**
Start time, t_1	sec	8:00:00	9:06:18	10:46:28
End time, t_2	sec	9:06:18	10:46:28	13:01:28
Measuring Period	sec	3978	6010	8100
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	1.80E-03	1.19E-03	8.82E-04
k in average, k_m	cm/sec	1.29E-03		

Permeability (Falling Head) Test

Date:	**6/7/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 13**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**			50.3	cm^2
Sample and Mould			**Condition of Specimen**			**Before Test**	**After Test**
Diameter	cm	10.2	**Weight of Specimen and Mould, M_a**	g		3316	3493
Cross-section Area, A	cm^2	81.7	**Weight of Specimen, M = M_a - m_m**	g		1466	1643
Length, L	cm	11.6	**Wet Density, ρ_t =**	g/cm^3		1547	1733
Volume, V=A*L	cm^3	0.948	**Moisture Content, ω**	%		16.3	39.9
Weight of mould	g	1850	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3		1330	1239
Soil Specific Gravity	Gs	2.179	**Void Ratio, e**			0.863	1.000
			Degree of Saturation, Sr	%		46.8	98.9

		1	2	3			
Start time, t_1	sec	7:30:00	8:59:23	10:22:26			
End time, t_2	sec	8:59:23	10:22:26	12:26:16		4983	
Measuring Period	sec	5363	4983	7430			
Difference of Head	cm	100	100	100			
Head of Water t_1, h_1	cm	158	158	158			
Head of Water t_2, h_2	cm	58	58	58			
Coefficient of Permeability, k	cm/sec	1.33E-03	1.43E-03	9.61E-04			
k in average, k_m	cm/sec	1.24E-03					

Permeability (Falling Head) Test

Date:	**5/28/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T -14**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**			50.3	cm^2
Sample and Mould			**Condition of Specimen**			**Before Test**	**After Test**
Diameter	cm	10.2	**Weight of Specimen and Mould, M_a**	g		3191	3613
Cross-section Area, A	cm^2	81.7	**Weight of Specimen, M = M_a - m_m**	g		1386	1808
Length, L	cm	11.6	**Wet Density, ρ_t =**	g/cm^3		1462	1907
Volume, V=A*L	cm^3	0.948	**Moisture Content, ω**	%		16.9	29.7
Weight of mould	g	1850	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3		1251	1471
Soil Specific Gravity	Gs	2.098	**Void Ratio, e**			0.981	0.685
			Degree of Saturation, Sr	%		42.7	107.4

		1	**2**	**3**
Start time, t_1	sec	8:30:00 AM	11:51:51 AM	3:04:32 PM
End time, t_2	sec	11:51:51 AM	3:04:32 PM	6:16:07 PM
Measuring Period	sec	12111	11561	11495
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	5.90E-04	6.18E-04	6.21E-04
k in average, k_m	cm/sec	6.10E-04		

Permeability (Falling Head) Test

Date:	**5/21/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 15**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**		50.3	cm^2
Sample and Mould			**Condition of Specimen**		**Before Test**	**After Test**
Diameter	cm	10.5	**Weight of Specimen and Mould, M_a**	g	3648	3779
Cross-section Area, A	cm^2	86.6	**Weight of Specimen, M = M_a - m_m**	g	1733	1864
Length, L	cm	11.6	**Wet Density, ρ_t =**	g/cm^3	1828	1967
Volume, V=A*L	cm^3	1.004	**Moisture Content, ω**	%	15.5	26.9
Weight of mould	g	1915	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3	1583	1550
Soil Specific Gravity	Gs	2.193	**Void Ratio, e**		0.565	0.599
			Degree of Saturation, Sr	%	67.9	111.3

		1	**2**	**3**
Start time, t_1	sec	8:00:00 AM	9:40:51 AM	11:25:09 AM
End time, t_2	sec	9:40:51 AM	11:25:09 AM	1:03:59 PM
Measuring Period	sec	6051	6258	5930
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	1.18E-03	1.14E-03	1.20E-03
k in average, k_m	cm/sec	1.18E-03		

Permeability (Falling Head) Test

Date:	**5/21/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 16**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**			50.3	cm^2
Sample and Mould			**Condition of Specimen**			**Before Test**	**After Test**
Diameter	cm	10.2	**Weight of Specimen and Mould, M_a**	g		3493	3678
Cross-section Area, A	cm^2	81.7	**Weight of Specimen, M = M_a - m_m**	g		1643	1828
Length, L	cm	11.6	**Wet Density, ρ_t =**	g/cm^3		1733	1929
Volume, V=A*L	cm^3	0.948	**Moisture Content, ω**	%		13.4	25.9
Weight of mould	g	1850	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3		1529	1532
Soil Specific Gravity	Gs	2.379	**Void Ratio, e**			0.621	0.618
			Degree of Saturation, Sr	%		53.5	103.9

		1	**2**	**3**
Start time, t_1	sec	8:00:00 AM	10:33:11 AM	12:58:15 PM
End time, t_2	sec	10:33:11 AM	12:58:15 PM	3:26:36 PM
Measuring Period	sec	9191	8704	8901
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	7.77E-04	8.21E-04	8.02E-04
k in average, k_m	cm/sec	8.00E-04		

Permeability (Falling Head) Test

Date:	**6/1/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 17**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**			50.3	cm^2
Sample and Mould			**Condition of Specimen**			**Before Test**	**After Test**
Diameter	cm	10.5	**Weight of Specimen and Mould, M_a**	g		3360	3592
Cross-section Area, A	cm^2	86.6	**Weight of Specimen, M = M_a - m_m**	g		1445	1677
Length, L	cm	11.6	**Wet Density, ρ_t =**	g/cm^3		1524	1769
Volume, V=A*L	cm^3	1.004	**Moisture Content, ω**	%		16.7	39.6
Weight of mould	g	1915	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3		1306	1267
Soil Specific Gravity	Gs	2.33	**Void Ratio, e**			0.897	0.955
			Degree of Saturation, Sr	%		46.1	102.7

		1	**2**	**3**
Start time, t_1	sec	8:00:00	10:20:39	12:36:59
End time, t_2	sec	10:20:39	12:36:57	14:47:45
Measuring Period	sec	8439	8178	7846
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	8.46E-04	8.73E-04	9.10E-04
k in average, k_m	cm/sec	8.77E-04		

Permeability (Falling Head) Test

Date:	**5/22/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 18**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**			50.3	cm^2
Sample and Mould			**Condition of Specimen**			**Before Test**	**After Test**
Diameter	cm	10.5	**Weight of Specimen and Mould, M_a**	g		3691	3818
Cross-section Area, A	cm^2	86.6	**Weight of Specimen, M = M_a - m_m**	g		1886	2018
Length, L	cm	11.5	**Wet Density, ρ_t =**	g/cm^3		1990	2129
Volume, V=A*L	cm^3	0.996	**Moisture Content, ω**	%		10.8	20
Weight of mould	g	1805	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3		1796	1774
Soil Specific Gravity	Gs	2.304	**Void Ratio, e**			0.380	0.397
			Degree of Saturation, Sr	%		70.4	124.9

		1	2	3
Start time, t_1	sec	8:00:00 AM	9:28:32 AM	12:20:54 PM
End time, t_2	sec	9:28:32 AM	12:20:54 PM	1:04:25 PM
Measuring Period	sec	5312	10342	2611
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	1.34E-03	6.91E-04	2.74E-03
k in average, k_m	cm/sec	1.59E-03		

Permeability (Falling Head) Test

Date:	**5/31/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 19**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**		50.3	cm^2
Sample and Mould			**Condition of Specimen**		**Before Test**	**After Test**
Diameter	cm	10.2	**Weight of Specimen and Mould, M_a**	g	3560	3716
Cross-section Area, A	cm^2	81.7	**Weight of Specimen, M = M_a - m_m**	g	1725	1881
Length, L	cm	11.6	**Wet Density, ρ_t =**	g/cm^3	1820	1984
Volume, V=A*L	cm^3	0.948	**Moisture Content, ω**	%	11	22
Weight of mould	g	1835	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3	1640	1627
Soil Specific Gravity	Gs	2.552	**Void Ratio, e**		0.511	0.523
			Degree of Saturation, Sr	%	53.3	104.2

		1	**2**	**3**
Start time, t_1	sec	7:30:00	9:42:42	12:03:15
End time, t_2	sec	9:42:42	12:03:15	14:14:45
Measuring Period	sec	7962	8433	7890
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	8.97E-04	8.47E-04	9.05E-04
k in average, k_m	cm/sec	8.83E-04		

Permeability (Falling Head) Test

Date:	**6/6/2016**	**Name:**	LOWER SHIRE VALLEY IRRIGATION
No.	**P/T - 20**	**Depth:**	0.0m - 1.0m

Glass Tube: Inside diameter =		8	**Cross Section Area, a =**			50.3	cm^2
Sample and Mould			**Condition of Specimen**			**Before Test**	**After Test**
Diameter	cm	10.2	**Weight of Specimen and Mould, M_a**	g		3440	3680
Cross-section Area, A	cm^2	81.7	**Weight of Specimen, M = M_a - m_m**	g		1605	1845
Length, L	cm	11.6	**Wet Density, ρ_t =**	g/cm^3		1693	1946
Volume, V=A*L	cm^3	0.948	**Moisture Content, ω**	%		12.2	27.7
Weight of mould	g	1835	**Dry Density, ρ_d = $\rho_t/(1+\omega/100)$**	g/cm^3		1509	1524
Soil Specific Gravity	Gs	2.264	**Void Ratio, e**			0.642	0.626
			Degree of Saturation, Sr	%		47.1	109.7

		1	**2**	**3**
Start time, t_1	sec	7:30:00 AM	9:22:33 AM	11:05:03 AM
End time, t_2	sec	9:22:33 AM	11:05:03 AM	12:37:18 PM
Measuring Period	sec	6753	6150	5535
Difference of Head	cm	100	100	100
Head of Water t_1, h_1	cm	158	158	158
Head of Water t_2, h_2	cm	58	58	58
Coefficient of Permeability, k	cm/sec	1.06E-03	1.16E-03	1.29E-03
k in average, k_m	cm/sec	1.17E-03		

Appendix K. Location Picture


BH-8
BH-9
BH-10
BH-14
BH-15
P/T-1
BH-16
BH-11
BH-12
BH-13


BH-16
BH-17
P/T-2
BH-18
BH-19
P/T-3
BH-20
BH-21
BH-22
P/T-4
BH-23
P/T-18
BH-24
P/T-20


BH-A


PT-5


PT-6


PT-7


PT-8


PT-9


PT-10


PT-11


PT-12


PT-13


PT-14


PT-15


PT-17


GPSmap 60CS
GARMIN


BH-2

Appendix L. Field Pictures


BH12
SN02
0.41–0.52M
BH12
SN04
0.85–1.35M
BH12
SN03
0.52–0.85M
BH12
SN05
1.35–2.80M
BH12
SN04
0.85–1.35M
BH12
SN05
1.35–2.80M
LEGEND
BHNO3
SNO8
6.25–7.50M
BHNO3
SNO7
5.45–6.25M
BHNO2
SETTING OUT
MACHINE

Appendix M. Lab Pictures